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Influence of Socioeconomic Determinants on Undernourishment in South Asia: A Panel Cointegration Analysis

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Abstract

Background: Undernourishment is a major public health challenge worldwide, with severe economic consequences. If occurs in the first years of life, it may cause long-lasting effect, particularly regarding personal development and economic growth of the country.

Objectives: The current study aimed to investigate the influence of socioeconomic factors, particularly education and national income, on undernourishment in selected countries of South Asia.

Methods: The annual panel data for 2001 to 2018 were analyzed using the vector error correction model (VECM) technique and the Toda-Yamamoto Granger causality test (TYGCT).

Results: According to the results of the VECM, adult literacy has mixed effects on undernourishment in the short run, while in the long term, it is associated with significant improvements in undernourishment. There is a negative association between economic growth and undernourishment in the short term; while, it disappears in the long term. The TYGCT is designed to validate the findings of the VECM as well as to investigate their robustness. According to the findings of the TYGCT, adult literacy alone can both improve undernourishment and enhance economic growth.

Conclusions: This study demonstrated a negative association between undernourishment and adult literacy rate in the long term; that is, higher literacy is associated with lower rates of undernourishment, which in turn results in improved community health. Adult literacy causes declined undernourishment and enhanced economic growth. Therefore, South Asian countries should incorporate appropriate interventions based on health and nutritional evidence in the curricula of schools to, firstly, gear up the nutritional awareness and, secondly, to strive redistribution of income among the relatively poor, which may reduce the undernourishment to a significant extent.

Keywords: Malnutrition, Economic Growth, Education

1. Background

Malnutrition is often caused by undernourishment, which is defined as receiving insufficient food for at least one year. In other words, undernourishment is the state of not fulfilling the energy requirements. It's about two years that the World Bank is publishing the prevalence of undernourishment as a percentage of the total population. In addition, the Food and Agricultural Organization of the United Nations (UNFAO) publishes undernourishment data as "number of the population undernourished in million" and as "prevalence of undernourishment as a percentage of the total population" both as three year-average starting from 2000. During the past two decades, the number of undernourished had declined; so that according to the estimates, in 2000, there were about 9000 million undernourished, and in 2017, it declined to 820.80 million (1), which shows a very slow improvement in the nutritional status of the world population. Thus, undernourishment still is a major public health challenge worldwide, particularly for South Asia, which, while hosting 25 percent of the world population, is a place of a low standard of living owing to low per capita income (2).

Undernourishment may cause by malnutrition, which directly affects human productivity and the economy of a nation. People who suffer from malnutrition in childhood generally face poor brain and physical development, which in turn causes poor mental health and cognitive skills, low academic performance during student-hood that is associated with limited job market placements or during their carrier. If occurs in the first years of life, undernourishment may cause long-lasting effect, particularly re-

garding personal development and economic growth of the country. A study (3) on South Asia explored the association between per capita income and life expectancy and reported a bidirectional causality. It is worth noting that a healthy population with high life expectancy has a crucial role in economic development. Sometimes undernourishment is used interchangeably with malnutrition, which has far-reaching consequences.

Several factors contribute to undernourishment, including economic, social, behavioral, and disease-related factors. In addition, many diseases such as diarrhea, dysentery, intestinal helminths [like hookworm, roundworm, and schistosomiasis], HIV, malaria, and respiratory infections can cause malnutrition in humans, which jeopardize both mental and physical health. Similarly, some behavioral factors also may cause malnutrition at different stages of life. For instance, child care and feeding practices as well as breastfeeding have a lasting effect on the growth of children's mental and physical health.

Food habits, complementary feeding practices, and health-seeking behaviors have an important role in determination of health and the life-expectancy of a community. In the current study, a special focus was made on socioeconomic factors, particularly national income [as a proxy for economic context and adult literacy [a proxy for social factor]. In addition, their influence on undernourishment in South Asia was also investigated.

Among all other factors, lack of economic access to necessary food could significantly justify undernourishment at the community level. Also, poor economic access, among other consequences, is the prime cause of malnutrition. Ensured economic access paves the way for economic growth. Generally, the benefits of economic growth should be distributed evenly, especially to the weaker sections of society in developing countries. Therefore, it is postulated that economic growth and improved income distribution are associated with improved nutrition. However, several studies raised concerns about the impacts of economic growth and improved income distribution on the nutritional status of those living in developing countries (4-6). Therefore, the current study aimed to investigate the influence of economic growth on undernourishment status in South Asia.

Education directly augments productivity, which in turn results in increased income and better access to foods, which translated into lower rates of undernourishment. There is evidence indicating the significant contribution of education in income level, even after realizing various costs of education. So that those with higher levels of education usually have higher levels of income, even in less-developed countries (7).

According to the literature, education is a major determinant of malnourishment. For instance, countries with adequate female literacy tend to have a lower prevalence of malnutrition, irrespective of differences in the countries' wealth or general living standards (8, 9). Curricula that emphasize basic health and nutritional knowledge not only can gear up the nutritional awareness but also can reduce the undernourishment among populations in South Asia.

There is plenty of literature on nutrition and undernourishment from medical and public health points of view. However, the literature on the impact of socioeconomic factors on undernourishment from the social science point of view is rare. A study (5) investigated the influence of food prices and several social variables on household health status in Indonesia and found that high commodity prices, health program service levels, and unsafe drinking water sources had a direct impact on the health status of family members. Another study (6) examined whether the rise in income led to increased nutrient intakes through analyses of subsample data from the "International Crops Research Institute for the Semi-Arid Tropics Village Level studies" panel data set for rural south India and reported that the real nutrient elasticities to income might be close to zero. The mechanism of the association between mother's education and child wellbeing has been investigated by a study conducted in Morocco and reported that mother's health knowledge is an important child-nurturing skill, which they gained outside school, but through knowledge and numeracy skills such knowledge can be achieved through classroom learnings (9). Hence, the study suggested that teaching health-related topics at schools could significantly uphold child health and nutritional status in Morocco. Several studies highlighted the role of education in raising income and argued that the potential gain was much higher than the costs of education (both direct and indirect), particularly in less-developed countries (7, 10).

Babar et al. (11) investigated the influence of socioeconomic factors on the nutritional status of children in the primary school of Pakistan using the data of a cross-sectional survey and mentioned poverty, lack of education, family size, food safety, and insecurity as important underlying factors responsible for poor health status. Kanjilal et al. (12) attempted to specify the extent of socioeconomic disparity in chronic childhood malnutrition across Indian states and identified the role of household socioeconomic status on the nutritional status of children. Wu et al. (13) investigated the association between socioeconomic progress and malnutrition among children younger than 5 years in China from 1990 to 2010 and reported a negative association between per capita income, size of family, and prevalence of malnutrition.

Khattak et al. (14) explored the association between

parental education and malnutrition based on a primary survey of 400 mothers commuting to primary health care centers in Pakistan. They reported that higher paternal and maternal educational status were significantly correlated with normal child nutritional status. It appeared that higher literacy among parents was associated with lower rates of malnutrition; hence, they argued that illiteracy is a main cause of undernourishment. Galgamuwa et al. (15) investigated the socioeconomic determinants of nutritional status among playschool and school-going kids in rural communities of Sri Lanka. They found that maternal employment, more siblings, high orders of birth, and female children were significantly connected with undernutrition among playschool children; while maternal employment, dwelling in tiny houses, larger family size, and little monthly income were significantly related to undernutrition among school-going children. Ravaoarisoa et al. (16) identified the socioeconomic determinants of maternal malnutrition in Madagascar following a cross-sectional design and found that larger family sizes and use of unsafe water were significantly associated with malnutrition.

Islam (3) examined the association between per capita income, adult literacy rate, and life expectancy at birth in several countries of South Asia. The study reported a bidirectional causality between life expectancy and per capita income; adult literacy and per capita income; and adult literacy and life expectancy. Islam (2), using time series annual data for the 1998 - 2017 period, has investigated the effects of education and health on food security in Bangladesh and documented a positive association between education expenditure and healthy community and food security in the country. Most of the above-cited studies examined the determinants of undernourishment and malnutrition based on cross-section data, and this study does the same based on macrolevel annual panel data.

2. Objectives

Hence, the present study investigated the impact of socioeconomic factors, namely literacy [a proxy for social factor] and national income [a proxy for economic factor], on undernourishment using rigorous econometric analysis from social science points of view, which the author believes to be a new contribution into the study of undernourishment.

3. Methods

3.1. Model Specification

In the present study, a model was specified to investigate the functional association between the number of undernourished people and adult literacy, as a proxy for social determinants, while the gross domestic product (GDP) was considered as a proxy for economic determinant (Equation 1 and Table 2).

$$NPU = f(ALR, LGDP) \quad (1)$$

Table 1. Variables Specification

Variable	Description	Source
NPU	The number of the population undernourished measured in million as a three-year average.	UNFAO
ALR	The adult literacy rate is expressed in percentage.	World Bank
LGDP	Natural logarithm of gross domestic product in terms of 2010 constant US dollars.	

The study used the annual panel data for the period of 2001 to 2018 collected from five selected South Asian economies (i.e. Bangladesh, Nepal, India, Pakistan, and Sri Lank, leaving the other three due to lack of sufficient data). We applied panel unit-root test, particularly for common unit root: Levin, Lin, and Chu (LLC); for individual unit root: Im, Pesaran and Chin W-test (IPS); ADF-Fisher chi-square; PP- Fisher chi-square; and Hadri tests. An optimum lag length following the Akaike Information Criterion (AIC) is used in the determination of unit-roots. After determining the stationarity of the panel, the Johansen-Fisher panel cointegration test is applied to identify the presence of cointegration among the above variables. This cointegration test is valid if variables are integrated at I (1).

For co-integrated panels, VECM is an appropriate estimation technique, which defines the long-run and short-run associations between variables, and also adjusts for both short-run fluctuations and the long-run effect of the panel data. It can directly estimate the level to which a variable can be brought back to equilibrium after any shock by other variables. Short-run effects are taken from individual coefficients of the differenced terms. Thus, the VECM allows us to estimate the long-run parameters and to analyze the short-run adjustment process. The general form of the VECM is presented in Equations 2-4.

$$\begin{aligned}\Delta NPU_t = \ & \alpha_1 + \sum_{i=1}^{l} \beta_{1i} \Delta NPU_{t-1} \\ & + \sum_{i=1}^{m} \gamma_{1i} \Delta ALR_{t-1} + \sum_{i=1}^{n} \delta_{1i} \Delta LGDP_{t-1} \\ & + \sum_{i=1}^{p} \epsilon_{1i} \Delta ECT_{t-1} + u_{1t} \ldots\end{aligned} \quad (2)$$

$$\Delta ALR_t = \alpha_2 + \sum_{i=1}^{l} \beta_{2i} \Delta NPU_{t-1} + \sum_{i=1}^{m} \gamma_{2i} \Delta ALR_{t-1} + \sum_{i=1}^{n} \delta_{2i} \Delta LGDP_{t-1} + \sum_{i=1}^{p} \epsilon_{2i} \Delta ECT_{t-1} + u_{2t} \ldots \quad (3)$$

$$\Delta LGDP_t = \alpha_3 + \sum_{i=1}^{l} \beta_{3i} \Delta NPU_{t-1} + \sum_{i=1}^{m} \gamma_{3i} \Delta ALR_{t-1} + \sum_{i=1}^{n} \delta_{3i} \Delta LGDP_{t-1} + \sum_{i=1}^{p} \epsilon_{3i} \Delta ECT_{t-1} + u_{3t} \ldots \quad (4)$$

ECT is the error correction term resulting from a long-run cointegrating association through Johansen's maximum likelihood procedure, uits are serially uncorrelated random errors with zero mean. Equation 2 is particularly used to investigate the causality from 'adult literacy' and 'national income' to undernourishment.

Further, the Toda and Yamamoto (17) Granger causality test is applied to uncover the causal association between NPU, ALR, and LGDP. The vector autoregressive (VAR) model, outlined in Equations 5-7, is used to test the Toda and Yamamoto Granger causality.

$$NPU_t = \alpha_{10} + \sum_{i=1}^{l+d_{max}} \alpha_{1i} NPU_{t-i} + \sum_{i=1}^{m+d_{max}} \beta_{1i} ALR_{t-i} + \sum_{i=1}^{n+d_{max}} \gamma_{1i} LGDP_{t-i} + u_{1t} \ldots \quad (5)$$

$$ALR_t = \alpha_{20} + \sum_{i=1}^{l+d_{max}} \alpha_{2i} NPU_{t-i} + \sum_{i=1}^{m+d_{max}} \beta_{2i} ALR_{t-i} + \sum_{i=1}^{n+d_{max}} \gamma_{2i} LGDP_{t-i} + u_{2t} \ldots \quad (6)$$

$$LGDP_t = \alpha_{30} + \sum_{i=1}^{l+d_{max}} \alpha_{3i} NPU_{t-i} + \sum_{i=1}^{m+d_{max}} \beta_{3i} ALR_{t-i} + \sum_{i=1}^{n+d_{max}} \gamma_{3i} LGDP_{t-i} + u_{3t} \ldots \quad (7)$$

The Toda-Yamamoto causality test is applicable in any order of integration [I(0) or, I(1) or I(2)] among panel variables, which makes it particularly suitable. However, to apply this test, the order of integration among variables is ascertained based on the Hadi unit root test results. In the above system of equations, d_{max} is the maximum possible order of integration of the variables, while l, m, and n are the optimal lag length of the respective variables, u_{1t}, u_{2t}, and u_{3t} are the error terms with zero mean, constant variance, and no autocorrelation.

4. Results

4.1. An Overview of Undernourishment in South Asia

The data in Table 2 shows that the number of the undernourished population has decreased over the years across the selected countries in which Nepal has been drastic, followed by Sri Lanka, Pakistan, and India, while in Bangladesh the figure was rising in absolute term. However, in a relative measure, the prevalence of undernourishment has decreased across all countries. Nepal has been much successful in terms of declining the prevalence, followed by Sri Lanka, India, Pakistan, and Bangladesh. Among the five countries, Nepal has the least prevalence, while India has the highest prevalence of undernourishment. There is an alarming need to improve the nutritional status of the population and improve the prevalence of undernourishment in South Asia.

In terms of raising the adult literacy rate, Bangladesh has been the most successful, followed by Nepal, India, and Pakistan. However, concerning the current rate of literacy, Sri Lank is at the top, followed by India, Bangladesh, Nepal, and Pakistan. However, there is a gulf of room to raise the adult literacy rates across the countries.

Investigating the values of GDP in the selected countries showed a continuous rise; thus, there has been steady growth over the study period. Achieving an appropriate distribution of benefits of economic growth is likely to improve the nutritional status of the people. The following sections examine the impact of adult literacy rates and economic growth on the undernourishment in selected countries of South Asia.

4.2. Unit Root Test Results

The results of the unit root test are presented in Table 3, which demonstrated that all three variables are non-stationary at their levels but stationary at the first difference, based on the majority of unit root tests (ADF, ERS, and PP). The Hadri test is specifically used for the Toda-Yamamoto Granger causality test only. Thus, the series are integrated at the same level, and they are I (1).

Table 2. Overview of the Study Variables[a]

Country	2001	2005	2010	2015	2016	2017	2018
Number of People Undernourished, Million							
Bangladesh	20.8	19.9	20.3	23.3	22.3	21.5	20.9
India	199.6	249.4	200.9	193.1	190.9	190.1	189.2
Nepal	5.7	4.3	2.7	1.7	1.6	1.7	1.7
Pakistan	31	28.4	30.4	25.4	24.6	24.8	26.1
Sri Lanka	3.2	2.9	2.1	1.8	1.7	1.6	1.6
Prevalence of Undernourishment, %							
Bangladesh	16	14.3	13.8	14.9	14.1	13.5	13
India	18.6	21.7	16.3	14.7	14.4	14.2	14
Nepal	23.6	16.9	9.9	6.4	6	6	6.1
Pakistan	21.2	17.7	16.9	12.8	12.1	12	12.3
Sri Lanka	17	14.8	10.4	8.7	8.3	7.8	7.6
Adult Literacy Rates							
Bangladesh	47.49	54.222	62.63	71.04	72.76	72.89	73.91
India	61.01	62.407	67.99	72.2	72.93	73.65	74.37
Nepal	48.61	53.016	58.53	64.36	65.54	66.73	67.91
Pakistan	49.28	49.874	55.38	57.7	58.41	59.13	59.53
Sri Lanka	90.68	90.784	91.18	92.19	92.39	91.9	91.71
GDP in Billion US Dollars at 2010 Prices							
Bangladesh	70.42	85.86	115.3	156.6	167.8	180	194.1
India	915.49	1193.87	1676	2295	2484	2659	2822
Nepal	11.42	12.88	16	19.77	19.89	21.53	22.97
Pakistan	120.9	150.18	177.2	215.6	227.6	240.2	254.2
Sri Lanka	33.74	41.633	56.73	76.49	79.92	82.78	85.51

[a] Source: The World Bank (18).

4.3. Johansen-Fisher Panel Cointegration Test Result

Based on the unit test results, the Johansen-Fisher panel cointegration test is conducted, and the results are reported in Table 4, which shows a cointegrating association between variables under investigation as the Fisher statistic both from the "Trace test and Max-Eigen test" are statistically significant.

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4.4. VECM Estimation Results

Since all variables are I(1), the VECM is applied to estimate the long run and short association between the variables. The lag order of the VAR model is derived as 7, LR, FPE, AIC, and HQ criteria are depicted in Table 5.

The lag order of the VECM is derived as 7 -1 = 6, and thus, Equation 2 with 6 lag for each variable is estimated and reported in Equation 8, which is the cointegrating equation and long-run model.

$$ECT_{t-1} = 1.00NPU_{t-1} + 3.6145ALR_{t-1} - 128.961 \quad (8)$$

5. Discussion

According to the Equation 8, there is a negative association between NPU and ALR, meaning that an increase in adult literacy leads to a decline in the number of undernourished people in the region. The finding is in line with the study by Glewwe (9), Babar et al. (11), and Khattak et al. (14), who reported the positive impact of education on nutrition. Literacy increases the awareness of the community about food requirements, which has positive influences on their demographic behavior, especially on reproductive health, child mortality rate, and life expectancy, and thus, it improves the overall health of the population. Moreover, educated people generally have higher levels of income, benefit from relatively higher purchasing power,

Table 3. Panel Unit Root Tests Results (Individual Intercept)[a]

Variable and Method		At Level		At 1st Diff	
		Statistic	Prob.	Statistic	Prob.
NPU					
LLC	Common unit root	-1.64641	0.0498	-3.03673	0.0012***
IPS	Individual unit root	-1.26307	0.1033	-3.70008	0.0001***
ADF	Individual unit root	14.8072	0.1392	32.5394	0.0003***
PP	Individual unit root	7.90720	0.6379	16.5139	0.0858
Hadri	Individual unit root	4.03006	0.0000	-0.24297	0.5960*
ALR					
LLC	Common unit root	1.80955	0.9648	-4.75628	0.0000***
IPS	Individual unit root	2.18306	0.9855	-5.19183	0.0000***
ADF	Individual unit root	4.63986	0.9139	66.6242	0.0000***
PP	Individual unit root	4.03941	0.9456	273.145	0.0000***
Hadri	Individual unit root	5.94110	0.0000	0.45966	0.3229*
LGDP					
LLC	Common unit root	2.88739	0.9981	-2.93437	0.0017***
IPS	Individual unit root	4.86471	1.0000	-3.55529	0.0002***
ADF	Individual unit root	0.95048	0.9999	31.1171	0.0006***
PP	Individual unit root	1.04631	0.9998	40.1118	0.0000***
Hadri	Individual unit root	6.00565	0.0000	1.29897	0.0970*

[a] Note: ***, **, and * denote significance at 1%, 5%, and 10% level respectively.

Table 4. Unrestricted Cointegration Rank Test Result[a]

Hypothesized	Fisher Stat.[a]		Fisher Stat.[α]	
Number of CE(s)	(from trace test)	Prob.	(from max-eigen test)	Prob.
None	66.77	0.0000***	47.00	0.0000***
At most 1	33.14	0.0003***	23.69	0.0085***
At most 2	25.98	0.0038***	25.98	0.0038***

[a] Note: α, probabilities are computed using asymptotic chi-square distribution; ***, denote significance at 1%, level.

and consequently, have more economic access to food. In addition, they have a higher awareness about health recommendations and food intakes that are useful to reduce undernourishment at the community level. The important implication of this finding is to raise the level, quality, and content of education among citizens of South Asian countries. The teaching of balanced and nutritious food requirements needs to be incorporated into the curricula of basic and primary education.

It further appears from the estimated Equation 8 that economic growth has no visible role in reducing undernourishment. Despite steady growth in South Asia, as documented in section 1 (Table 1), the benefits of economic growth are not equally shared by the poor sections of the societies. This finding is in contrast with Kanjilal et al. (12), Wu et al. (13), Galgamuwa et al. (15), Islam (2), and Islam (3), who reported a negative association between malnutrition and income. However, it acknowledges the finding of Behrman and Deolalikar (6), who found the true nutrient elasticities to income close to zero. The finding has important policy implications for policymakers to strive to redistribute income among the relatively poor sections of the community.

5.1. Short-Run Dynamics

The estimated short-run model output is demonstrated in Table 6, and the association is presented in Equation 9. The negative and statistically significant coefficient

Table 5. VAR Lag Order Selection Criteria[a]

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-610.9405	NA	995987.2	22.32511	22.43460	22.36745
1	-12.82335	1109.235	0.000495	0.902667	1.340631	1.072031
2	9.941651	39.73527	0.000301	0.402122	1.168558	0.698509
3	45.42020	58.05580	0.000116	-0.560734	0.534175*	-0.137324
4	51.59453	9.429884	0.000130	-0.457983	0.965399	0.092450
5	74.08440	31.89474	8.19e-05	-0.948524	0.803331	-0.271068
6	87.49011	17.54929	7.24e-05	-1.108731	0.971596	-0.304252
7	101.9317	17.32990*	6.26e-05*	-1.306607*	1.102193	-0.375105*

Abbreviations: AIC, Akaike information criterion; FPE, final prediction error; HQ, Hannan-Quinn information criterion; LR, sequentially modified LR test statistic (each test at 5% level); SC, Schwarz information criterion.
[a]Note: *, indicates lag order selected by the criterion.

of ECT (C(1)) validates the cointegration among the variables.

$$\begin{aligned}\Delta NPU_t = & -0.0083ECT_{t-1} + 0.5737\Delta NPU_{t-1} \\ & + 0.3635\Delta NPU_{t-5} + 0.2505\Delta NPU_{t-6} \\ & - 0.4531\Delta ALR_{t-1} + 0.5381\Delta ALR_{t-3} \\ & - 21.3526\Delta LGDP_{t-1} \\ & - 23.9019\Delta LGDP_{t-3} + 2.0065 \ldots\end{aligned} \quad (9)$$

D(NPU) = C(1)*(NPU(-1) + 3.61454669523*ALR(-1) - 6.63748554726*LGDP(-1) - 128.960858239) + C(2)*D(NPU(-1)) + C(3)*D(NPU(-2)) + C(4)*D(NPU(-3)) + C(5)*D(NPU(-4)) + C(6)*D(NPU(-5)) + C(7)*D(NPU(-6)) + C(8)*D(ALR(-1)) + C(9)*D(ALR(-2)) + C(10)*D(ALR(-3)) + C(11)*D(ALR(-4)) + C(12)*D(ALR(-5)) + C(13)*D(ALR(-6)) + C(14)*D(LGDP(-1)) + C(15)*D(LGDP(-2)) + C(16)*D(LGDP(-3)) + C(17)*D(LGDP(-4)) + C(18)*D(LGDP(-5)) + C(19)*D(LGDP(-6)) + C(20).

The lag values of the dependent variable influence functional association, past values of undernourishment cause further undernourishment in the short run. Adult literacy has a mixed impact, while economic growth harms undernourishment in the short run. Unlike, in the long run, economic growth improves nutritional status in the short run.

The model provides a good fit reflected by the values of R-squared, adjusted R-squared, Durbin-Watson statistic, and that of F-statistic.

5.2. Toda-Yamamoto Granger Causality Test Results

The optimum lag order is determined based on the LR, FPE, AIC, and HQ criteria, as reported in Table 5. The direction of causality among the variables based on the Toda-Yamamoto causality test is determined using $d_{max} = 1$ and reported in Table 7.

There is a unidirectional causality running from ALR → NPU as the null hypothesis "ALR does not Granger cause NPU" is rejected at a 1% level, meaning that adult literacy rates significantly cause undernourishment. Therefore, South Asian countries need to incorporate proper teachings interventions on basic health and nutritional knowledge in the curricula at schools to gear up the nutritional awareness, which may reduce the undernourishment among populations to a significant extent. No causality is found between LGDP and NPU. The finding reinforces the VECM results and evidences its robustness.

The second unidirectional causality exists from ALR to LGDP as the null hypothesis "ALR does not Granger cause LGDP" is rejected at a 1% level, indicating that education takes care of rising income leading to economic growth. The finding is insightful and acknowledges the findings in the literature (3, 7).

5.3. Conclusions

The present study intended to investigate the impact of adult literacy rates and economic growth on undernourishment in the selected countries of South Asia. The Johansen-Fisher panel cointegration test confirms a cointegrating association between undernourishment, adult literacy, and economic growth in Bangladesh, India, Nepal, Pakistan, and Sri Lank.

The VECM estimation provides evidence in favor of a long-run negative association between undernourishment and adult literacy rate in South Asia, as it makes a community-conscious about the food intake and improves health. Also, educated people have more earnings and relatively higher purchasing power, which translated into more economic access to food that contributes to reduced undernourishment in the long run.

In the short term, there is a negative association between economic growth and undernourishment; however,

Table 6. The VECM Short-Run Estimation Results[a]

Coefficient	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.008334	0.003120	-2.671432	0.0114**
C(2)	0.573702	0.123574	4.642600	0.0000***
C(3)	-0.245364	0.145919	-1.681506	0.1016
C(4)	-0.020866	0.146718	-0.142221	0.8877
C(5)	0.158621	0.128340	1.235945	0.2247
C(6)	-0.363455	0.099282	-3.660850	0.0008***
C(7)	0.250468	0.063375	3.952158	0.0004***
C(8)	-0.453066	0.242873	-1.865446	0.0705*
C(9)	-0.042034	0.258683	-0.162494	0.8719
C(10)	0.538067	0.272868	1.971892	0.0566*
C(11)	0.390797	0.235383	1.660259	0.1058
C(12)	0.038472	0.268603	0.143230	0.8869
C(13)	-0.113230	0.218050	-0.519287	0.6068
C(14)	-21.35264	7.510337	-2.843100	0.0074***
C(15)	5.054283	8.911591	0.567158	0.5742
C(16)	-23.90185	8.993595	-2.657653	0.0118**
C(17)	3.589238	9.806903	0.365991	0.7166
C(18)	-5.776459	9.277014	-0.622664	0.5375
C(19)	-6.745378	7.671670	-0.879258	0.3853
C(20)	2.006492	0.858434	2.337387	0.0253**
R-squared	0.906448	Durbin-Watson stat		1.852877
Adjusted R-squared	0.855662	F-statistic		17.84854***

[a] Note: ***, **, and * denote significance at 1%, 5%, and 10% level respectively.

Table 7. Toda-Yamamoto Granger Causality Test Results

Null Hypothesis	Chi-sq	df	Prob.	Direction of Causality
ALR does not Granger cause NPU	23.29481	8	0.0030***	ALR → NPU, unidirectional
NPU does not Granger cause ALR	12.93240	8	0.1142	
LGDP does not Granger cause NPU	9.589230	8	0.2950	No causality
NPU does not Granger cause LGDP	10.66906	8	0.2212	
LGDP does not Granger cause ALR	6.695411	8	0.5698	ALR → LGDP, unidirectional
ALR does not Granger cause LGDP	22.80829	8	0.0036***	

[a] Note: ***, denote significance at 1% level.

it disappears in the long term; thus, economic growth improves nutritional status in the short-run only.

The Toda-Yamamoto Granger causality revealed two unidirectional causalities, ALR → NPU and ALR → LGDP, indicating that adult literacy alone takes care of improving undernourishment and increasing economic growth. Therefore, it is recommended that South Asian countries should incorporate proper teachings on basic health and nutritional knowledge in the curricula at schools to gear up the nutritional awareness and to strive for redistribution of income among the relatively poor, which may reduce the undernourishment among populations to a significant extent.

Footnotes

Authors' Contribution: The manuscript has been written by Md. Saiful Islam completely.

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