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Research Article

Environmental and Socio-Economic Drivers of Child Anthropometric Failures in Selected Countries of South Asia

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ABSTRACT

The pervasiveness of malnutrition among children under five is unacceptably high in South Asia. Assessment of overall burden of malnutrition with summation of Gomez and Waterlow's three class divisions in Svedberg formulated Composite Index of Anthropometric Failure (CIAF) and Nandy's revised CIAF have overlooked the incidence of over nutrition and their possible connections with other subgroups. This study proposes a new scheme; an extended version of CIAF as developed by Kuiti and Bose, to accurately estimates the prevalence of anthropometric failures. The study also examines the effects of socio-economic and environmental variables on child malnutrition in selected South Asian countries including Pakistan, India and Bangladesh. For empirical analysis, panel co-integration technique is employed by using data for the period 1990 to 2018. All the variables are stationary at first difference. Fully Modified OLS (FMOLS) method is applied to explore the parameter estimates. The results showed that political stability, prevalence of undernourishment, anemia in children, mother's education, household size, dependency ratio, air pollution and unimproved sanitation significantly correlated with childhood under nutrition. The findings also testified to long-run co-integrating relationship among the variables.

Keywords: ECIAF; Air pollution; Mother's education; Malnutrition; Co-integration; South Asia; Anthropometric failure

INTRODUCTION

Health is an engine of economic growth. The health of women, mothers and children in particular is fundamental to economic development. Healthy children are the linchpin for healthy and thriving societies as reflected by the agenda of Millennium and sustainable development goals. Child nutrition and health affects economic growth directly and indirectly in many ways. Directly it plays a pivotal role in establishing the foundations of human capital investment and reduction in economic burden of illnesses. Indirectly it impacts economic growth *via* affecting the future income of people through the impact health has on education [1].

Childhood malnutrition manifests in three broad forms: Under nutrition, which includes stunting (low height for age), wasting (low weight for height) and underweight (low weight for age), over nutrition (overweight and obesity) and micronutrient-related malnutrition. There is no as such confirmatory test to measure under nutrition and over nutrition. Anthropometry is a pragmatic and immediately applicable technique for measuring children's development patterns during the first five years of his/her life. It quantifies the nutritional situation at one point of time and allows comparisons overtime [2].

Child anthropometry in South Asia

Child nutritional anthropometry is a serious health issue, highly prevalent especially in developing and poor nations. According to the WHO global estimates, South Asia and Africa experienced the highest proportions of anthropometric failures. Around 87 million stunted children dwell in Asia, 59 million are inhibited in Africa and just 6 million are the part of Caribbean regions and Latin America. Nearly 16 million children are affected by severe acute malnutrition (wasting) across the globe. These statistics are staggering and confirmed that malnutrition is a global health issue [3]. Similar patterns are seen in the

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prevalence of underweight, highest in Asia and Africa and lowest prevalence have been observed in other parts of the world. Besides this what we see in the headlines, 38 million children under five are found to be overweight and obese. A new nutrition reality, the distribution of childhood malnutrition is budging from a predominance of under nutrition to a dual burden of under and over nutrition. Globally more deaths are linked to overweight and obesity than underweight. This novel and complex problem of overlapping forms of malnutrition is a significant barrier to sustainable development in these nations [4].

More than half of the malnourished children of South Asia live mainly in Pakistan, Bangladesh and India. Children have some stubbornly high global rates of stunting and wasting in the region, known as South Asian enigma. The number of stunted children under the age of five is around 38 percent in Pakistan, 32 percent in Bangladesh and 30 percent in India. According to the global nutrition report, Pakistan and India was reported the home of almost half of all stunted children around the globe carrying 10.7 million and 46.6 million stunted children respectively (UNICEF). India is one of the three countries with the most wasted children, having 25.5 million wasted children. Bangladesh is on course to prevent childhood wasting but still 9.8 % children are affected by wasting which is higher than the average for the Asia region (8.9%). Pakistan is also making some progress towards achieving the target for wasting but still 7.1% children are affected. The report also highlights the worrying incidence and universality of malnutrition in all its forms, the changing face of malnutrition in Asia. The prevalence of overweight among children under five is 2.5%, 1.6% and 2.4% in Pakistan, India and Bangladesh respectively [5].

The trend is clear: Progress is too slow to meet the global targets. No South Asian country is on course to meet all ten of the 2025 global nutrition targets. Malnutrition has been reached at an alarming stage and reflects twin presence of under nutrition and over nutrition among children. Almost a quarter of all children under 5 are stunted. At the same time, overweight is increasing rapidly with no signs of slowing [6].

Research objective

One way to achieve those nutrition targets is to accurately measure the overall burden of malnutrition among children under five (outcome variable) and find the factors which are responsible for this exceptional scale of under nutrition and over nutrition. Empirically, many studies have tried to fulfill the underlying objective. All of the above are South Asian studies and have found that the most common factors associated with child malnutrition in South Asia are poor maternal health, low maternal literacy rate, lower GDP growth rates, poor health care services, government instability, food unavailability and poor access, poor hygiene and other ecological factors. All the studies have used conventional indices of anthropometric failures to determine child malnutrition status in South Asia [7]. Nevertheless these standard estimates mirror distinct biological processes but have the problem of overlapping. Thus they are unable to provide the correct and comprehensive measure of undernourishment in the study subjects. For instance, a number of stunted children will also have wasting; others might be experiencing the concurrent burden of stunting and underweight. Some children might face concomitant prevalence of all three indicators. Consequently these primitive indices as can't truly detect the overall burden of malnutrition [8].

An eminent Swedish development economist, Peter Svedberg has firstly proposed CIAF model in 2000. That contains six (A to F) mutually exclusive subgroups to determine the aggregate prevalence of malnutrition. Later on Nandy modified it by adding one more group labeled (Y) and challenged its usefulness over the primitive method of anthropometric measurements; stunting, wasting and underweight. However with the emergence of dual burden of malnutrition, this CIAF model of classification is not sufficient as it does not address the issue of concomitant coexistence of stunting with overweight among children under five. Since over the last three decades, the high prevalence of overweight among children has been confirmed by many studies [9]. Several recent studies have reported the presence of overweight and obesity simultaneously with stunting, *i.e.,* low HAZ among children under five. This study includes estimated overweight levels in children and its possible connections with other anthropometric indicators in the CIAF model as defined by, labeled as (G and H) and examines its trends at different time periods in selected countries of South Asia. Although a significant and robust association of existence between high weight for height and obesity is observed, yet greater lean body mass can also be a consequence of high weight for length. Therefore obesity should not be employed to depict high weight for height on individual basis. It is only considered adequate for a wide population having majority of the obese sample subjects [10].

Although there are so many Indian and a few Bangladeshi and Pakistani studies that have used CIAF as a proxy for child malnutrition. Yet to the best of authors' knowledge, no study has been done exclusively on South Asia using CIAF model to identify the hidden vulnerabilities among the children under five. This model represents the better estimate of overall burden of malnutrition among the children as compared to conventional indices of stunting, wasting, underweight and overweight. It is important to estimate the extent and pattern of malnutrition among children by exploring further dimensions of the hidden under nutrition "iceberg". In this context, this paper will obviously fill this gap by examining the overall burden of malnutrition and their determinants in selected countries of South Asia [11].

MATERIALS AND METHODS

Predictors

Variables used to decompose the change in coincidence of growth disorders among children under five were demographic and socioeconomic characteristics of household (household size, dependency ratio, female literacy rate and political stability), nutritional characteristics (prevalence of anemia among children under five and prevalence of undernourishment), and environmental characteristics (unimproved sanitation facilities and ambient particulate matter pollution). These variables are correlated with child nutritional status in prior empirical studies. The theoretical justification of the variables used in the multivariate analysis is given below turn by turn [12].

Female literacy rate

Social determinants of child health such as female education are strongly associated to health seeking behavior and improving overall health outcomes of their children. Education of women reflected as higher literacy rates is related with higher incomes and better health indicators such as lower infant mortality, child malnutrition and population growth rates. Women education has a 'multiplier effect' on the wellbeing of their children. Educated women tend to marry at a later age, have fewer children and be more informed about nutrition requirement and healthcare practices of their children. Therefore there exists a negative correlation between female literacy rate and child death. Thus, the coefficient α is expected to be negative [13].

Ecological quality Indicators

This study used two indicators of ecological quality; one is air pollution and the other is unimproved sanitation facility. Emerging evidence suggests that adverse ecological conditions and pollution is a major contributor to childhood malnutrition and mortality particularly in developing countries. Children are particularly vulnerable to certain environmental risks, including: Air pollution and inadequate sanitation also found a potential relationship between ambient air pollution and child growth indicators.

Similarly unimproved sanitation was also found to be a significant predictor of anthropometric failures amongst children under five. Assessed that the sanitation in terms of sanitation ladder frequently contribute to child growth failures and may bring the source of faecal contamination to the doorstep of the households. Therefore environmental risks have an impact on the health and development of children. Thus, the coefficient α is expected to be positive [14].

Political stability

Malnutrition is often considered a political problem as the constant instability aggravates the food and sanitation situation in the country. Political stability rests on a government's ability to carry out its proclaimed programs and provide reliable public services to the commons. It creates conditions that are conducive to economic stability of the households, the functioning of markets for essential nutrition inputs such as food and keep food price at levels. Children are particularly vulnerable to food insecurity resulting from food price spikes. The effects are likely to be the increased incidence of stunting, wasting and other growth disorders among children. Therefore it is claimed that political stability is estimated to have large and permanent effects on nutrition status and plays a significant role for reducing childhood under nutrition along with other socio-demographic factors. Thus, the coefficient α is expected to take a positive sign [15].

Prevalence of under nourishment

Undernourishment refers to the condition of insufficient intake of food. It can lead to serious health issues, including impaired growth and obesity in children. Therefore the effect of complementary feeding practices reflects in severely jeopardized health of children under five. The coefficient of Prevalence of undernourishment is contemplated to be positive [16].

Anemia in children

Identified that severe chronic anemia may lead to child health variables such as stunting, wasting, underweight and overweight. The likely cause of childhood anemia is delayed growth problems among children under five. Thus, the coefficient is expected to take a positive sign [17].

Dependency ratio

Malnutrition is not only a health sector problem. Demographic factors like high household dependency ratios and large household size, which are mainly the social determinants, are detrimental to children's nutritional outcomes and inequalities. Thus, the coefficient is expected to take a negative sign [18].

Household size

The study also attempts to examine the impact of economic growth and health expenditures as a percentage of GDP on child under nutrition in South Asia but find no synergistic effects and the value of the coefficient of economic growth and public health expenditure will remain insignificant in the equation of child's malnutrition status. The role of economic growth in reducing child under nutrition remains an open and highly debated question. Economic growth does not necessarily help countries to decrease undernourishment; this outcome is only found significant for South Asia [19].

Economic growth is indispensable but not enough factors required combating undernourishment. The reason could be the substantial disparity in the share of poor people in the aggregate economic growth. Similarly the actual relationship between health spending and child health is still unclear, particularly at the macro level as most of the researchers found an insignificant association between health expenditure and under five malnutrition. Health care expenditures as a percentage of GDP are not a dominant driver to childhood malnutrition. Household water supply facilities were also not significantly associated with concurrent prevalence of child's anthropometric failures [20].

Data sources and description

Nationwide cross-sectionals are employed to capture the health status of children under five over the past three decades for Pakistan, India and Bangladesh. There are five available cross-sections for Pakistan for the period of 1990-2018. These include PDHS (1990-1991), NNS (2001-2002), NNS (2011), PDHS (2012-2013) and PDHS (2017-2018). PDHS (2006-2007) is not utilized for the current analysis as it doesn't consist of anthropometric indicators. For this reason the study used NNS

(2001) to fill the huge time gap between 1991 to 2012. Similarly Indian available data sets for the same time period are PDHS's (1992-1993), (1998-1999), (2005-2006) and (2015-2016). Seven data sets are available for Bangladesh. These include PDHS's (1990), (1996-1997), (2004), (2007), (2011), (2014) and (2017-2018).

Data for exposure variables such as female literacy arte, household size, dependency ratio, prevalence of Anemia in children and prevalence of undernourishment is taken from World Development Indicators (WDI) of World Bank for Pakistan, Bangladesh and India for the period of 1990 to 2018. Data for political stability was derived from international country risk guide as one of the six dimensions of good governance. Data for household unimproved sanitation facilities was extracted from WASH data source. Data for ambient particulate matter pollution was downloaded from GBD data visualizations and the Global Health Data Exchange (GHDx), IHME's catalog of the world's health and demographic data.

The methodological approach consists of zooming in on this data through several interrelated steps. The first step involves the construction of an Extended Version of Composite Index of Anthropometric Failures (ECIAF) which represents our main contribution to a better operationalization of malnutrition among children under five within the selected region. We identified the vulnerable distinct subgroup as pointed out in Table 1 and compared the ECIAF index with other conventional indices. The next step incorporates the shifting conditions of under nutrition and over nutrition with respect to different time periods within the selected region. The third step involves different econometrics steps to investigate the association between child anthropometric failures and socioeconomic and environmental determinants. Firstly we check the data stationarity through the unit root test. After confirming that the data is stationary at first difference, we will check the co-integration.

This test is used to find the longrun association among the dependent variable and explanatory variables. For this purpose, Kao and Johansen's-Fisher panel co-integration tests have been employed. These tests are very effective and suitable for panel study. The last step is to employ the advance panel data econometric techniques known as Fully Modified Ordinary Least Square (FMOLS) along with descriptive statistics. The study examined the short-run affiliation and long-run association between nominated potential confounders and child anthropometric failures for selected South Asian countries (Pakistan, Bangladesh and India).

Panel econometric equation: ECIAF f (dependency ratio, household size, female literacy rate, prevalence of undernourishment, prevalence of anemia in children under five, air pollution, unimproved sanitation facilities and political stability).

ECIAF=β^0+β^1 (Dependency ratio)+β^2 (household size)+β^3 (female literacy rate)+β^4 (prevalence of undernourishment)+β^5 (prevalence of anemia)+β^6 (air pollution)+β^7 (unimproved sanitation facilities)+β^8 (political stability)+μ it CIAF=β^0+β^1 (DR)+β^2 (HHS)+β^3 (FLR)+β^4 (POU)+β^5 (POA)+β^6 (AP)+β^7 (USF)+β^8 (PS)+μ it

This study has calculated WHZ (wasting), WAZ (underweight) and HAZ (stunting) scores by using ENA for smart software with reference to WHO standards. Whereas descriptive analysis and other computations has been done utilizing SPSS version 20. Panel econometric analysis has been done by using EViews 12.

RESULT AND DISCUSSION

Operationalization of Extended version of Composite Index of Anthropometric Failures (ECIAF), the outcome variable

The first step involves estimating the anthropometric indices. Anthropometric indices are constructed using the information on children's weight, recumbent length, (<24 months or child unable to stand without support) stature (>24 months), age in months, and their gender. Four key anthropometric indicators are calculated, these includes height for age (stunting), weight for age (underweight), weight for height (wasting) and overweight. Stunting refers to impaired growth and development, experienced by children less than five years of age, used as the marker of chronic malnutrition. In more logical terms, stunting can be defined as height for age z scores is (<-2 SD), below the average according to the WHO child growth standards. Wasting signifies a severe course of weight loss and defined as weight for age z scores are (<-2 SD), below the average according to the WHO child growth standards. Underweight for age mirrors body mass corresponding to chronological age and a diagnostic of weight for age z scores (<-2 SD) with reference to the WHO standards. Whereas overweight can be examined as a combination of two terms, high weight for height and high weight for age. It is defined as weight for height z scores and weight for age z scores are (>2 SD) above the average according to the WHO reference values.

There are three generally accepted procedures of assessing child growth statuses. Among these, the study used the method of creating z scores. In the first step, we took the difference between child's height or weight (relative with the age and gender) and the mean/median values for the reference population. Then in the second step Z score is computed by dividing this difference with the standard deviation of the reference group. This can be written as follows in case of calculating height for age z scores.

$$\text{Z-score} = \frac{Hi - Hr}{\textit{Standard deviation of the refrence population}} \qquad (1)$$

Where, Hi stand for the estimated height of the child and Hr is the median height of the reference group. The number of the children whose z score is below minus 2SD is undernourished. The world health organization proposed as reference population. This reference is formed on the basis of the anthropometric indicators of the children of six countries.

ECIAF model: The ECIAF model with mutually exclusive categories is elaborated as under Table 1.

Table 1: A portrayal of the categories of ECIAF among children.

Groups	Descriptions	Explanation of the levels	Wasting	Stunting	Underweight	Overweight
A	No failure	Standard levels of WAZ,WHZ and HAZ	No	No	No	No
B	Wasting only	Only WHZ is below -2 SD	Yes	No	No	No
C	Wasting and underweight	WHZ and WAZ are below -2 SD, but HAZ is in normal range	Yes	No	Yes	No
D	Wasting, stunting and underweight	WHZ, HAZ and WAZ, all are below -2 SD	Yes	Yes	Yes	No
E	Stunting and underweight	HAZ and WAZ, are below -2 SD, but WHZ is in normal range	No	Yes	Yes	No
F	Stunting only	Only HAZ is below -2 SD	No	Yes	No	No
G	Stunting and overweight	If WHZ and WAZ are above 2 SD	No	No	No	Yes
H	Overweight only	If HAZ is below -2 SD and WHZ and WAZ are above 2 SD	No	Yes	No	Yes
Y	Underweight only	WAZ is below -2 SD	No	No	Yes	No

ECIAF model equation: Lastly, the following formula has been proposed to detect normal, undernourished and over nourished children among the studied populations.

$$\text{ECIAF}=\frac{1-A}{((A+B+C+D+E+F+Y)+(G+H))} \qquad (2)$$

Definition and construction of predicted variables

Dependency ratio, household size, mother's education, prevalence of undernourishment within the population, anemia in child, household unimproved sanitation, air pollution and government stability are the selected as the potential risk factors. Dependency ratio is calculated by adding the percentage of children under the age of 15 years and older population above the age of 64 years divided by the percentage of independents in the household (15-64) year then multiplied by 100. Household size is the total number of members in a family. Mother's education is the total years of schooling of child's mothers. Prevalence of undernourishments is the percentage of the population whose habitual food intake is not enough to provide the dietary energy levels, required to maintain a normal active and healthy life. Child anemia is a condition referred to as low hemoglobin lack of enough healthy red blood cells, or high rates of red blood cell destruction among children under five. Environmental degradation is proxied by air pollution and household unimproved sanitation. While air pollution is the ambient particulate matter pollution (micrograms per cubic meter) and unimproved sanitation is the share of population with access to unimproved sanitation facilities.

Child malnutrition trends within the selected region

An amalgam of anthropometric failures for children has been calculated by employing the above ECIAF model to examine variation in malnutrition over the successive time periods in selected South Asian region. The results are as under Table 2.

Table 2: Co-existing anthropometric failures according to the different classification of malnutrition among children in Pakistan.

Co-existing prevalence of anthropometric failures among Pakistani children						
Groups	**Possible categories of anthropometric failures**	**PDHS (1990-1991) n=4043**	**NNS (2001-2002) n=8895**	**NNS (2011) n=27887**	**PDHS (2012-2013) n=3153**	**PDHS (2017-2018) n=4236**
A	No failure	1443 (35.7)	4104 (46.1)	12101 (43.4)	1441 (45.7)	2287 (54)
B	Wasting only	90 (2.2)	346 (3.9)	1176 (8.9)	92 (2.9)	90 (2.1)
C	Wasting and underweight	131 (3.2)	441 (5)	1538 (10)	92 (2.9)	128 (4.9)
D	Wasting, stunting and underweight	197 (4.9)	432 (4.9)	1408 (5)	156 (4.9)	119 (2.8)
E	Stunting and underweight	1047 (25.9)	1547 (17.4)	4924 (22.3)	551 (17.5)	647 (16.6)
F	Stunting only	889 (22)	1445 (16.2)	4514 (27.2)	559 (17.7)	782 (24.5)
G	Stunting and overweight	124 (3.1)	236 (2.7)	1125 (6.1)	152 (4.8)	73 (1.7)
H	Overweight only	59 (1.5)	198 (2.2)	607 (4.8)	64 (2.0)	72 (1.7)
Y	Underweight only	63 (1.6)	146 (1.64)	494 (3.9)	46 (1.5)	38 (0.9)
ECIAF (%)		64.3	53.9	56.6	54.2	46

As the single growth retardation symptom, stunting is the largest among all the other problems of under nutrition and over all the time periods. Similarly the greatest number of children is affected by the double burden of stunting and underweight among all the possible combinations. Wasting and overweight problems have been increased from (1991-2002) but reduced later while co-occurrence of wasting and underweight have increased in the same time cohort, reduced between 2002-2013 but rises again in 2018. Incidence of double burden of stunting and overweight has also the same trend (Table 3).

Table 3: Comparison of ECIAF with conventional indices among Pakistani children (under five).

Conventional indices of anthropometric failures	**PDHS (1990-1991) n=4043**	**NNS (2001-2002) n=8895**	**PDHS (2012-2013) n=3153**	**PDHS (2017-2018) n=4236**
Stunting	2257 (55.8)	3624 (40.7)	1418 (45)	1621 (38.3)
Wasting	418 (10.3)	1251 (14.1)	331 (10.5)	335 (7.9)
Underweight	1438 (35.6)	2530 (28.4)	845 (26.8)	930 (22)
Overweight	183 (4.5)	474 (5.3)	225 (7.1)	145 (3.4)
ECIAF (%)	64.3	53.9	54.2	46

It is evident that ECIAF aggregate detects more undernourished children as compared to stunting, wasting and underweight separately as it identifies 64.3%, 53.9%, 54.2% and 46% more malnourished proportions in children respectively from 1990-2018. The prevalence goes on decreasing periodically. However a major percentage improvement has been observed between the periods of 1990 to 2002 (Table 4).

Table 4: Coexisting anthropometric failures according to the different classification of malnutrition among children in Bangladesh.

Co-existing prevalence of anthropometric failures among children of Bangladesh								
Groups	**Possible categories of anthropometric failures**	**BDHS (19901991) n=5351**	**BDHS (1996-1997) n=4706**	**BDHS (2004) n=6186**	**BDHS (2007) n=5535**	**BDHS (2011) n=7647**	**BDHS (2014) n=7256**	**BDHS (2017-2018) n=7806**
A	No failure	2158 (40.8)	1316 (28)	2532 (40.9)	2465 (44.5)	3568 (46.7)	3694 (50.9)	4641 (59.5)
B	Wasting only	94 (4.1)	113 (7.7)	138 (5.1)	169 (6.3)	228 (5.9)	234 (5.9)	194 (3.9)
C	Wasting and under weight	208 (7.8)	321 (17)	259 (8.3)	352 (10.9)	429 (9.5)	418 (9.1)	241 (4.6)
D	Wasting, stunting and Under weight	356 (6.7)	529 (11.2)	469 b (7.6)	427 (7.7)	528 (6.9)	405 (5.6)	229 (2.9)
E	Stunting and under weight	1493 (32.1)	1491 (40.8)	1653 (31.4)	1251 (27.6)	1540 (24.3)	1292 (21.2)	1087 (15.6)
F	Stunting only	827 (27.5)	746 (36.2)	909 (26.4)	625 (20.2)	992 (21.8)	870 (19.1)	1091 (19)
G	Stunting and overweight	22 (0.7)	57 (2.7)	31 (0.9)	17 (0.5)	50 (1.1)	35 (0.8)	38 (0.6)
H	Overweight only	20 (0.8)	31 (1.6)	26 (0.8)	43 (1.3)	71 (1.6)	64 (1.7)	114 (2.4)
Y	Underweight only	146 (6.2)	102 (7)	169 (6.2)	186 (6.9)	241 (6.2)	243 (6.2)	171 (3.5)
ECIAF (%)		59.2	72	59.1	55.5	53.3	49.1	40.5

Child malnutrition firstly increases and then decrease over the successive time periods. Malnutrition is highest within the time span of 1996-1997 and lowest during 2017-2018. With respect to single growth retardation problems, stunting is the highest and regarding double burden of malnutrition, coexistence of stunting and underweight is highest among all (Table 5).

Table 5: Comparison of ECIAF with conventional indices among pakistani children (under five).

coexisting prevalence of anthropometric failures among children of Bangladesh							
Conventional indices of anthropometric failures	**BDHS (1990-1991) n=5351**	**BDHS (1996-1997) n=4706**	**BDHS (2004) n=6186**	**BDHS (2007) n=5535**	**BDHS (2011) n=7647**	**BDHS (2014) n=7256**	**BDHS (2017-18) n=7806**
Stunting	2698 (50.4)	2823 (60)	3062 (49.5)	2320 (41.9)	3110 (40.7)	2602 (35.9)	2445 (31.3)
Wasting	656 (12.3)	958 (20.4)	866 (14)	948 (17.1)	1184 (15.5)	1057 (14.6)	660 (8.5)
Underweight	2203 (41.2)	2443 (51.9)	2550 (41.2)	2216 (40)	2738 (35.8)	2359 (32.5)	1728 (22.1)
Overweight	44 (0.8)	93 (2)	57 (0.9)	60 (1.1)	122 (1.6)	100 (1.4)	156 (2)
ECIAF	59.2	72	59.1	55.5	53.3	49.1	40.5

ECIAF showed a higher prevalence of under nutrition in comparison to other three traditional indicators that is stunting, wasting, overweight and underweight among all time span. Therefore it is established that ECIAF is a better indicator of child nutritional status than traditional measures because it determines overall anthropometric failure (Table 6).

Table 6: Coexisting anthropometric failures according to the different classification of malnutrition among Indian children.

coexisting prevalence of anthropometric failures among Indian children					
Groups	**Possible categories of anthropometric failures**	**IDHS (1992-1993) n=26755**	**IDHS (1998-1999) n=24855**	**IDHS (2005-2006) n=43498**	**IDHS (2015-2016) n=225002**
A	No failure	8958 (33.5)	9337 (37.6)	18497 (42.5)	99224 (44.1)
B	Wasting only	977 (9.8)	1001 (9.7)	1934 (9.3)	13587 (12)
C	Wasting and underweight	1537 (12.8)	1499 (12.1)	2771 (11.3)	18063 (13.3)
D	Wasting, stunting and underweight	2517 (9.4)	2088 (8.4)	3223 (7.4)	14492 (6.4)
E	Stunting and underweight	7077 (33.8)	5580 (28.8)	9161 (26.5)	39753 (22.9)
F	Stunting only	4346 (32.7)	3960 (29.8)	6006 (24.5)	29052 (20.5)
G	Stunting and overweight	490 (3.5)	536 (3.8)	531 (2.1)	3016 (2.3)
H	Overweight only	321 (3.5)	338 (3.5)	444 (1.8)	2508 (2.5)
Y	Underweight only	532 (5.4)	516 (5.2)	931 (4.7)	5307 (5.1)
ECIAF (%)		66.5	62.4	57.5	55.8

Child anthropometric failures are highest during 1992-1992 and lowest during 2015-2016. The stunting prevalence among children is highest within all-time spans and coexistence of stunting and underweight is highest with respect to double burden of growth retardation (Table 7).

Table 7: Comparison of ECIAF with conventional indices among children (under five).

Conventional indices of anthropometric failures	**IDHS (1992-1993) n=26755**	**IDHS (1998-1999) n=24855**	**IDHS (2005-2006) n=43498**	**IDHS (2015-2016) n=225002**
Stunting	14429 (53.9)	12163 (48.9)	18921 (43.5)	86312 (38.4)
Wasting	5000 (18.7)	4557 (18.3)	7900 (18.2)	45915 (20.4)
Underweight	11663 (43.6)	9683 (39)	16086 (37)	77615 (34.5)
Overweight	843 (3.2)	906 (3.6)	1003 (2.3)	5752 (2.6)
ECIAF (%)	66.5	62.4	57.5	55.8

The above table depicts that measurement of underweight, stunting, wasting and overweight under-estimates the burden of malnourishment. Although conventional indices gives valuable information and must not be disregard-ed, as CIAF it-self is constructed from the aggregation of these indices. Yet Composite Index of Anthropometric Failure (CIAF) better estimate the burden of under nutrition as it reveals additional dimensions of the malnutrition iceberg. The following graph shows the different time trends in child malnutrition among Pakistan, Bangladesh and India from 1990-2018 (Figure 1).

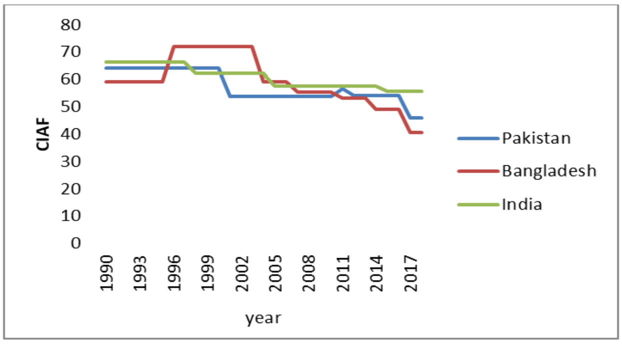

Figure 1: Trends of ECIAF over time among children in Pakistan, Bangladesh and India.

Panel econometric analysis

Panel unit root test: We cannot apply first generation panel unit root tests to test the stationarity of the variables as cross-section units are not cross-sectionally independent. We will use second-generation panel unit root test of Pesaran that allow for cross-section dependence. The panel unit root test conforms that all the variables are stationary at first difference (Tables 8 and 9).

Table 8: Descriptive analysis of the outcome and exposure variables.

Variables	Mean	Maximum	Minimum	Std. Dev	Skewness	Interquartile range	Kurtosis
ECIAF	59.36	72	40.5	7.04	-0.08	10	3
Dependency ratio	68.39	89.37	48.95	11.63	0.23	18.2	2.08
Household size	6.91	9.33	4.71	1.54	0.28	3	1.54
Female literacy rate	42.58	71.18	16.4	13.61	0.12	24	2.16
Prevalence of undernourishment	17.29	59.3	10.8	5.35	5.63	3.5	44.86
Anemia in children	60.74	77.1	40.3	8.66	-0.32	12	2.76
Air pollution	63.84	95.24	51.64	10.29	1.01	14.48	3.56
Unimproved sanitation	23.11	47.85	2.14	14.96	0.05	30	1.59
Political stability	0.622	0.85	0.41	0.12	0.32	0.23	2.22

Table 9: Results of FMOLS.

Variables	FMOLS
Dependency ratio	0.457622^{***}(14.59788)
Household size	0.126385^{***}(1.992739)
Female literacy rate	0.139380^{***}(-1.221118)
Prevalence of undernourishment	0.107692^{***}(2.650631)
Anemia in children	0.542698^{***}(7.704404)
Air pollution	0.259938^{***}(3.293111)

Unimproved sanitation	0.210710***(3.353972)
Government stability	-4.591377***(-60.82759)
R^2	0.83574
Adjusted R^2	0.813239
S.E. of regression	3.005688
Observations	87

Note: t values are given in parentheses *** (*) show that value is statistically significant at 1% (10%) level

Discussion of the FMOLS results

The study analysed pooled weighted FMOLS as proposed by Pedroni and Kao and Chiang, in order to allow different long run variances across the cross section for heterogeneous panels. The test statistics show that all variables are significant and t value of dependency ratio, household size, government stability, and female literacy rate, Prevalence of undernourishment among the studied population, access to unimproved sanitation, air pollution and anemia in children under five strongly affect child anthropometric failures and performing a significant role in reducing under-five child malnutrition. The findings in case of dependency ratio and household size depict positive and significant effects on the prevalence of composite growth retardation problems among children under five and unveil that one unit increase in both the variables positively influences undernourishment by 0.46 units and 0.13 units respectively. The literacy rate among women of reproductive age is found to be negative and significant. Prevalence of undernourishment within the studied population and anemia in children under five would also increase anthropometric failures among children In case of air pollution and unimproved sanitation facility, our results show that one unit increase in both the variables would increase child malnutrition by 0.26 and 0.21 respectively. The elasticity coefficient of government stability is found to be negative and significant. Therefore, there is an inverse relationship between government stability and child malnutrition in South Asian countries. Thus the higher the government stability, the lower would be the prevalence of growth retardation among children and vice-versa (Table 10).

Table 10: Results of Johansen-fisher panel co-integration test.

Johansen-fisher panel co-integration test				
	Individual intercept		**Individual intercept and trend**	
	Fisher statistic trace test	**Probability**	**Fisher statistic (Max eigen test)**	**Probability**
None	194.5	0.0000	72.56	0.0000
At most 1	356.2	0.0000	122.6	0.0000
At most 2	167.8	0.0000	90.63	0.0000
At most 3	108.4	0.0000	31.21	0.0000
At most 4	82.41	0.0000	23.60	0.0006
At most 5	65.61	0.0000	21.69	0.0014
At most 6	52.55	0.0000	23.17	0.0007
At most 7	39.76	0.0000	30.16	0.0000
At most 8	20.09	0.0027	20.09	0.0027

H_0: Variables are not co-integrated. All variables are distributed normal, N (0, 1). *** And ** means significant at 1% and 5% respectively. Fisher's test is employed irrespective of independent variable. Lag intervals for test: 1 1, Asymptotic p-values are estimated by employing χ^2 distribution tests. Here we see that in case of none hypothesized co-integrated equation; the probability value is less than 0.05. Therefore we reject our null hypothesis and conclude that the variables have a long run association. With the same fashion, in at most 1, at most 2 and all the remaining hypothesized co-integrated equations, all the probabilities are less than 0.05. Therefore we reject our null hypothesis and state that the variables under consideration are co-integrated and have long run associations (Table 11).

Table 11: Results of KAO residual co-integration test.

KAO residual conintegration	
ADF test statistic	-3.292257
Significance	0.0005

As the probability of ADF test statistic is less than 0.05 so we reject our null hypothesis and conclude that the variables are co-integrated and have a long run association.

CONCLUSION

The prime focus of this study is to determine the severity and extent of concomitant prevalence of anthropometric failure among children under five and the impact of potential confounders on overall burden of child malnutrition within the time span of in Pakistan, Bangladesh and India. The findings of this study revealed that the extended version of CIAF model as employed by this study, accurately measure the overall burden of under nutrition and over nutrition in a single figure. Since underestimating the size of hidden vulnerable subgroups might deprive a substantial number of children from getting the advantage of extra supplementation and care they urgently need. In this context, this malnutrition index reflects a wider view of the extent and pattern of malnutrition among children under five by exploring further dimensions of the hidden under nutrition iceberg. Moreover it represents the better estimate of overall burden of malnutrition among the preschoolers as compared to conventional indices of stunting, wasting, underweight and overweight. Thus it has potential implications to be used as a tool for screening systems of malnutrition, monitoring of nutritional interventions and tracking achievement of millennium development goals.

All the associated risk factors significantly influence the under-five malnutrition problem in all the three countries. The education of women of reproductive age (mothers) is a cornerstone for the betterment of child survival and health. An educated mother, through knowledge and awareness can better deal with risk factors associated with child malnutrition. Thus improvement in mother's education improves the feeding and weaning practices of their children. Household demographics also play an important role in the healthy upbringing of their children. The findings of this research also implied that children less than 5 years of age living at houses with access to unimproved sanitation facilities and air pollution had increased the danger of child malnutrition. Children learn to crawl and walk at this stage of their age, can experience more exposure to pathogens that is the prime cause of diarrhea from different environmental sources. Similarly emerging environmental threats including air pollution have also been linked to increased risk of childhood anthropometric failures. Political stability is found to be an essential determinant of child health outcomes. It has been investigated that growing political stability leads to strengthen social and health programs, may reduce child malnutrition.

RECOMMENDATIONS

Unquestionably, the cumulative impact of the several underlying factors escalating the severity of under nutrition and over nutrition problem in South Asian countries is thought-provoking and requires a considerable commitment and solemnity by the governments to address this issue. At first extended version of CIAF approach should be adapted to accurately measure and recognize the size of all hidden vulnerable groups for better policy formulation and trend monitoring of childhood malnutrition. Efforts should be made to improve household sanitation and air pollution condition may need to be considered an integral part of the programmatic responses by governments and development partners for the prevention of under-five child health status. Improving overall household living conditions, increasing maternal education can lead to reduce malnutrition. To combat occurrence of undernourishment and anemia, the authorities should take steps to improve the quantity and quality of available food as well as the food prices should also be controlled and manage them at a pace to make food affordable for the commons. Enhance food and nutrition knowledge by education programs and public awareness campaigns to maintain healthy life styles and dietary practices. Focus on first crucial thousand days, and promote healthy feeding and weaning practices among the children to combat obesity. The health ministry and the government should prioritize and initiate nutrition intervention programs of food fortification with multiple micronutrients and additional supplementation of vitamin A at the national, provincial and district levels with special emphasis on children as the builders of the nation.

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