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Original Research Article

Finding sustainable solutions for childhood under-nutrition in India: an assessment of association of childhood under-nutrition with multiple factors

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ABSTRACT

Background: Burden of malnutrition among children is very high in India. Under-nutrition is an interplay of different factors. The present study tried to understand the correlation between child under-nutrition and different distal and proximate factors.
Methods: Correlation coefficients (r), using state wise data, were calculated to assess relationship between child nutritional status and other factors such as minimum acceptable diet, micronutrient deficiencies, IYCF, maternal nutritional factors, women agency, water and sanitation practices, HDI, food insecurity and climate change vulnerability.
Results: Minimum acceptable diet showed negative correlation with childhood wasting (-0.41) and stunting (-0.36). They were positively correlated with any form of anaemia and vitamin A deficiency. Both basic and age-appropriate immunisation was negatively correlated with wasting (r=-0.2 and -0.5 respectively) and stunting (r=-0.5 and -0.7 respectively). Maternal nutritional factors (BMI<18.5 kg/m^2 and any form of maternal anaemia) were positively correlated with childhood nutritional status. Strong negative correlation of both wasting and stunting were found with households having toilet facilities (r=-0.7 in both cases). Indoor air pollution was positively correlated with wasting (r=0.6) and stunting (r=0.2). Both wasting (r=-0.50) and stunting (r=-0.70) were negatively correlated to HDI. Food insecurity and climate change vulnerability were positively correlated with both wasting (r=0.3 for both case) and stunting (r=0.6 and 0.40 respectively).
Conclusions: A synergetic programme that brings together essential nutritional interventions and those that address underlying and basic causes is required to sustainably address childhood under-nutrition in India.

Keywords: Wasting, Stunting, Childhood undernutrition, Correlation

INTRODUCTION

India has faced with triple burden of malnutrition-undernutrition (stunting, wasting and underweight), hidden hunger or micronutrient deficits and obesity. Current Comprehensive National Nutrition Survey (CNNS) data shows that 17% children below 5 years of age were wasted, 35% were stunted and 33% were underweight.[1] Undernutrition among children is a result of an interplay between proximate factors like inadequate dietary intake and diseases, underlying factors - household food insecurity, suboptimal feeding and caring practices.

Other determining factors are lack of healthcare access and unhealthy household environment, societal structures and processes that neglect human rights and perpetuate

poverty and limit or deny the access of vulnerable populations to essential resources.[2,3]

Eradicating malnutrition in all forms have been globally enshrined in the Sustainable Development Goals (SDGs). India has shown strong political commitment to attaining 2030 Agenda for Sustainable Development, with NITI Ayog entrusted with the task of coordinating the SDGs to ensure policy initiatives for inclusive development coverage.[4,5] SDGs take into account three dimensions of development- economic, social and environment, and seeks to provide solutions in a sustainable, equitable, efficient, and environmentally sustainable manner. While SDG 2 directly aims at eliminating malnutrition in all forms, other SDGs also have a bearing on nutritional outcomes. SDG-1 specifies ending poverty, the basic cause of malnutrition in all forms with equitable distribution of resources and building resilience. SDG 2 also talks about food accessibility, agricultural productivity and resilient, sustainable food systems. SDG 3 targets good health and well-being and aims at reducing maternal and child mortality. SDG-4 aiming to ensure inclusive and equitable quality education, has a strong impact on nutritional outcomes through higher parental education and economic productivity. SDG-5 (on gender equality) and SDG-6 (clean water and sanitation) address the underlying causes of undernutrition among children. SDG 7 on access to clean energy is interlinked with nutritional outcomes in light of growing body of evidence linking indoor air pollution to low birthweight. SDG 13 specifically talks of climate change that has a strong bearing on livelihood, health and nutrition, especially for the vulnerable communities.

Poshan Abhiyan (National Nutrition Mission) launched in 2018 is in sync with the SDG goals. The Abhiyan envisages a multi-sectoral convergence strategy for sustainable solution of undernutrition in India, with specific targets to reduce stunting, under-nutrition, anaemia (among young children, women and adolescent girls) and reduce low birth weight.[6] It aims at inter departmental convergence of health, women and child development, water and sanitation, rural development and Panchayati Raj, tribal affairs, urban development, education, food and public distribution systems, information and broadcasting and Niti Ayog for monitoring antenatal check-ups and institutional deliveries, breastfeeding, complementary feeding and growth monitoring, management of acute malnutrition, prevention and treatment of anaemia, micronutrient supplementation, diarrhoea management and food fortification.[7]

In light of Poshan Abhiyan, this paper has analysed the household level and macro-factors that are affecting child undernutrition today. The purpose of this analysis is to identify factors which are affecting child undernutrition to highlight the need of inter departmental convergence between for sustainably reduce the problem of malnutrition among children.

METHODS

CNNS is a nationally representative nutrition survey of children and adolescents in India conducted by Ministry of Health and Family Welfare (MoHFW), Government of India (GoI) between 2016 and 2018. The present study conducted correlation analyses using the secondary data published by different ministries of GoI and India specific data published by United Nation Development Programme (UNDP). Correlation analyses were conducted using the state wise data on childhood wasting and stunting from CNNS in reference to minimum acceptable diet, micronutrient deficiencies, infant and young child feeding, maternal nutritional factors (from CNNS 2016-18). The correlation analyses of childhood wasting and stunting from CNNS were also conducted with other parameters such as women empowerment and domestic violence, water and sanitation (WASH) (using National Family Health Survey (NFHS-4) data collected by MoHFW, GoI in 2015-16), human development index (HDI) data of 2020 (published by UNDP), hunger data (published by Department of Food and Public Distribution, GoI) and climate change vulnerability data of 2019-20 (published by Department of Science and Technology, Government of India and Swiss Agency for development and Cooperation).[8-11]

Correlation coefficients (r) were calculated in SPSS Version 23.0 (IBM SPSS Statistics for Windows, Version 20.0. Armonk, New York, USA: IBM Corp) to measure the strength of the relationship between the nutritional indicators and the above variables. Since contemporary data for WASH was not available in CNNS, data on child undernutrition and WASH indicators were taken from NFHS-4 for one analysis.

WHO defines minimum acceptable diet (MAD) is the proportion of children aged 6-23 months who received at least the minimum dietary diversity (MDD) and the minimum meal frequency (MMF) in the previous day. Minimum dietary diversity refers to the proportion of children aged 6-23 months who received foods from four or more food groups. Minimum meal frequency refers to proportion of breastfed and non-breastfed children 6–23 months of age who received solid, semi-solid, or soft foods (but also including milk feeds for non-breastfed children) the minimum number of times or more.[12]

CNNS has used the following cut-offs for defining micronutrient deficiencies: anaemia if haemoglobin was <11g/dl for children aged less than 5 years, Vitamin A deficiency (VAD) if serum retinol concentration <0.20 µg/dl, vitamin B12 deficiency if serum vitamin B12 level <203 pg/ml, folate deficiency if serum erythrocyte folate level <151 ng/ml; for zinc deficiency cut-off of <65 µg/dl for children below 10 years in fasting condition was taken, vitamin D deficiency was taken as serum 25(OH)D concentration using a cut-off of <12 ng/ml (30 nmol/l) among children 1-9 years.

Basic immunization includes BCG, measles, and three doses each of DPT and polio vaccine (excluding polio vaccine given at birth) and age- appropriate immunization means BCG, measles, four doses of hepatitis B, and three doses each of DPT and polio vaccine (excluding polio vaccine given at birth) as per child's age).[8]

Improved source of drinking water includes piped into dwelling/yard/plot, public tap/standpipe, tube well or borehole, protected dug well, protected spring, rainwater, community RO plant. Solid cooking fuel Includes coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crop waste, and dung cakes.[8] Women's participation in decision making included making decisions either alone or jointly with husband in all 3 aspects: women's own health care, making major household purchases and visits to her family or relatives.[8]

People covered under National Food Security Act (NFSA) was taken as a proxy indicator for food insecurity. Beneficiaries under NFSA are eligible for subsidized food grain.[10]

RESULTS

Childhood undernutrition and minimal acceptable diet

Table 1 shows that providing MAD to a child aged 6-23 months is associated with reduced risk of wasting and stunting. MDD showed a higher degree of negative correlation with wasting and stunting (Correlation coefficient (r) was -0.44 and -0.51 respectively), while correlation with MMF was inconclusive and needs to be probed further. Correlation coefficient (r) of overall MAD for wasting was -0.41 and for stunting was -0.36.

Table 1: Correlation between childhood undernutrition among children aged 6-23 months and minimum acceptable diet.

Indian States	Children with WHZ≤2SD	Children with HAZ≤2SD (%)	Minimum dietary diversity	Minimum meal frequency	Minimum acceptable diet
Andhra Pradesh	16.4	31.5	11.9	22	1.3
Arunachal Pradesh	8.7	28	37.5	55.8	20.6
Assam	24.5	32.4	24.7	38.9	6.5
Bihar	13.6	42	13.2	53.7	6.1
Chhattisgarh	23.4	35.4	17.6	57.1	10.8
Delhi	17.6	28.8	29.7	24.9	6.4
Goa	14.3	19.6	31.6	23	3.1
Gujarat	20.2	39.1	16.5	30.2	3.6
Haryana	12.1	34.9	30.8	30.7	6.5
Himachal Pradesh	14.6	28.4	41.1	40.9	13.6
Jammu & Kashmir	19.2	15.5	39.2	31.1	7.1
Jharkhand	26.4	36.2	11.6	60.6	6.7
Karnataka	18.8	32.5	18.3	31.6	3.6
Kerala	11.8	20.5	52.8	65.9	32.6
Madhya Pradesh	23.8	39.5	16.4	54.2	5.9
Maharashtra	18.9	34.1	16.5	26.9	2.2
Manipur	7.2	28.9	37.9	30.1	8.3
Meghalaya	16.4	40.4	62.3	28	7.7
Mizoram	7.3	27.4	19.8	32.8	2.8
Nagaland	11.7	26.2	20.3	46.9	5.6
Odisha	15.4	29.1	31	54.3	17
Punjab	9.9	24.3	41.2	22.6	7.4
Rajasthan	13.1	36.8	11.6	43.6	3.5
Sikkim	6.9	21.8	58.8	67.4	35.9
Tamil Nadu	19.4	19.7	36.5	24.1	4.2
Telangana	19	29.3	13.2	31.8	3.6
Tripura	13.4	31.9	24.3	62.5	16.9
Uttar Pradesh	22.1	38.8	16.7	45.1	4.8
Uttarakhand	5.5	29.9	34.1	38.1	12.2
West Bengal	16.7	25.3	42.9	36.7	12.9
Correlation wasting			-0.44	-0.02	-0.41
Correlation stunting			-0.51	0.13	-0.36

Table 2: Correlation of wasting with micronutrients deficiencies in 1-4 years children in India.

State	Children with WHZ ≤≤2SD (%)	Children with HAZ ≤2SD (%)	VAD (%)	Zinc Deficiency (%)	Anaemia Any (<11.0 g/dl)	Anaemia Mild (10.0-10.9 g/dl)	Anaemia Moderate (7.0-9.9 g/dl)	B12 Deficiency (%)	Folate Deficiency (%)
Andhra Pradesh	17	31.5	20.8	10	39.6	22.7	13	11.1	62.7
Arunachal Pradesh	7.2	28	14.8	8.4	28.3	19.3	9	7	38
Assam	22.1	32.4	21.4	27.1	33.7	24.8	8	2.8	59.9
Bihar	15.9	42	14.3	22.4	43.7	24.3	18	13.8	6.1
Chhattisgarh	21.6	35.4	26.6	18.6	40.8	23.3	17	21.1	43.7
Delhi	14.6	28.8	17.8	18.9	47	18.7	27	7.8	1.3
Goa	15.4	19.6	2.4	25.6	22.1	17.2	4	3.2	16.6
Gujarat	16.1	39.1	14.6	19.8	38.2	16	22	29.2	39.4
Haryana	12.5	34.9	26.1	6.2	48.3	22.9	23	11.6	14.6
Himachal Pradesh	12.9	28.4	5.9	41.1	29.7	17.4	12	6.9	4.6
Jammu and Kashmir	13.8	15.5	8.7	21.4	27.1	14.6	10	7.9	5.9
Jharkhand	25.5	36.2	43.2	28.4	43.7	30.3	13	17.6	5.3
Karnataka	19.6	32.5	9.6	20.1	34.7	15.5	16	15.4	36
Kerala	12.9	20.5	17.1	9	12.5	9.2	3	3.4	18.4
Madhya Pradesh	17	39.5	27.1	22.3	53.5	23.6	28	11.6	57.6
Maharashtra	19.5	34.1	9.4	12.3	41.6	18.5	21	11.8	42.2
Manipur	5.6	28.9	17.1	26.6	10	7.3	3	4.3	6.4
Meghalaya	12.3	40.4	6.3	14.3	32.9	22	9	8.5	26.1
Mizoram	6.8	27.4	39.2	4.6	24.4	19.1	5	6.3	17.9
Nagaland	11.9	26.2	23.6	0.9	8	8	0	12.4	74.1
Odisha	10	29.1	19.8	18.7	37.2	23.8	12	7.2	34.4
Punjab	6.6	24.3	17.2	21	39.8	19.1	20	17.1	9.8
Rajasthan	13.1	36.8	4.5	9.1	32.4	15.2	16	15.6	34
Sikkim	8.9	21.8	2.7	22.4	33	21.1	11	6.5	0.1
Tamil Nadu	19.7	19.7	13.1	20.1	27.3	14.6	12	6.6	23.9
Telangana	19	29.3	26.5	10.1	37.8	17.5	20	12.4	46.8
Tripura	14	31.9	20.6	17.1	33	23	10	6	1
Uttar Pradesh	17.6	38.8	17.1	22.1	43	22.4	20	23.2	6.1
Uttarakhand	6	29.9	14.3	22.4	32.4	12.9	14	19	17.6
West Bengal	18.3	25.3	5	15.2	45.7	31.2	14	1.9	0.3
Correlation Wasting			0.2	0.2	0.4	0.5	0.3	0.2	0.2
Correlation Stunting			0.3	0.0	0.5	0.4	0.3	0.2	0.2

Table 3: Correlation between childhood under-nutrition among 12-23 age group and immunization.

	Children with WHZ≤2SD (%)	Children with HAZ≤2SD (%)	All basic vaccinations	Age-appropriate vaccinations
Andhra Pradesh	16.7	31.5	65.2	28
Arunachal Pradesh	8.6	28	38.2	10.9

Continued.

	Children with WHZ≤2SD (%)	Children with HAZ≤2SD (%)	All basic vaccinations	Age-appropriate vaccinations
Assam	27.6	32.4	47.1	14.2
Bihar	14.7	42	61.7	24.4
Chhattisgarh	22.2	35.4	76.4	35.7
Delhi	19	28.8	68.8	27.4
Goa	11.7	19.6	88.4	74.5
Gujarat	17.6	39.1	50.4	11.8
Haryana	13.2	34.9	62.2	35
Himachal Pradesh	10.8	28.4	69.5	42.6
Jammu & Kashmir	16.8	15.5	75.1	50.7
Jharkhand	25	36.2	61.9	17.9
Karnataka	18.6	32.5	62.6	29.8
Kerala	12.8	20.5	82.1	53.4
Madhya Pradesh	24.9	39.5	53.6	25.4
Maharashtra	19	34.1	56.2	24.8
Manipur	5.1	28.9	65.8	3.5
Meghalaya	12.4	40.4	61.4	20.4
Mizoram	7	27.4	50.7	17.4
Nagaland	12	26.2	35.4	15.4
Odisha	12.2	29.1	78.6	56.4
Punjab	7.5	24.3	89	77.6
Rajasthan	14.6	36.8	54.8	21.7
Sikkim	8.2	21.8	83	60.6
Tamil Nadu	12.1	19.7	69.7	43.1
Telangana	18.9	29.3	67.5	34.9
Tripura	12.3	31.9	54.5	17.1
Uttar Pradesh	20.6	38.8	51	12.8
Uttarakhand	6.2	29.9	57.6	21.2
West Bengal	13.4	25.3	84.4	38
Correlation wasting			-0.2	-0.2
Correlation stunting			-0.5	-0.6

Childhood undernutrition and micronutrient deficiencies

Wasting and stunting were found to be positively corelated with micronutrient deficiencies (Table 2). Anaemia showed a strongest association; correlation coefficient (r) for any form of anaemia was 0.4 for wasting and 0.5 for stunting; whereas it was 0.5 and 0.4 respectively for mild anaemia and 0.3 for both stunting and wasting for moderate anaemia. Correlation coefficient for VAD was 0.2 for wasting and 0.3 for stunting. Vitamin B12 deficiency and Folate deficiencies had a correlation coefficient (r) of 0.2 for both stunting and wasting. Zinc deficiency also had a correlation coefficient (r) of 0.2 with wasting, but such correlation was not evident for childhood stunting.

Child undernutrition and illness prevention

Immunization provides protection against life threatening childhood illnesses, and thus reduces risk of mortality. This study found immunization as a protective factor against childhood undernutrition. Table 3 shows that the correlation coefficient (r) of basic immunization with wasting was -0.2 and with stunting was -0.5, implying higher rate of immunization was associated with lower risk of both forms of undernutrition. Similarly, correlation coefficient (r) of age-appropriate immunization with wasting was -0.5 and with stunting was -0.6; this correlation was stronger compared to basic immunization.

Childhood undernutrition and environmental factors

Improving environmental conditions reduces the risk of illness, and thereby lowers the chances of a child being undernourished. Table 4 shows strong negative correlation of both childhood wasting and stunting with households having toilet facilities (r=-0.7 in both cases). A negative correlation was also seen between childhood wasting and households' access to improved source of drinking water (r=-0.1), however, the correlation between stunting and improved drinking water source is counter-intuitive, and needs further probing. Indoor air pollution generated from burning solid fuels was also positively corelated with childhood wasting (r=0.6) and stunting (r=0.2).

Table 4: Correlation of childhood undernutrition among children aged 0-59 months with household food insecurity, hdi, environmental factors and maternal factors.

					Environmental Factors				Maternal Aneamia			Maternal Factors		
State	Child-ren with WHZ ≤2SD (%)	Child-ren with HAZ ≤2SD (%)	Propor-tion of food insecure house holds	Human Develop-ment Index (HDI)	State vulnerab-ility index (climate change)	HH with improved source of drinking water	With toilet facility	Using solid fuel for cooking	Mild	Moder-ate	Severe	Maternal BMI<18.5 kg/m^2	Women's participation in decision making	Domestic Violence (physical or sexual)
Andhra Pradesh	17.1	31.5	49.63	0.65	0.51	72.7	61.3	37.1	39.6	18.5	60	17.6	58.9	43.9
Arunachal Pradesh	6.8	28	53.74	0.66	0.59	87.5	90.8	54.2	33.4	9.1	43.3	8.5	76.9	28.4
Assam	19.4	32.4	70.54	0.614	0.62	83.8	88.9	74.2	37.1	8.3	46	25.7	71	24
Bihar	14.5	42	69.93	0.576	0.61	98.2	33.5	81.9	45.7	13.9	60.3	30.5	51.8	38.7
Chhattisgarh	19.3	35.4	67.9	0.613	0.62	91.1	41.3	76.7	37.8	8.4	47	26.7	65.9	34.5
Delhi	14.8	28.8	39.14	NA	NA	80	96	1.6	40.1	12.6	54.3	14.8	56.3	26.4
Goa	15.8	19.6	34.34	0.761	0.43	96.3	89.1	13.7	24.8	5.8	31.3	14.7	83.7	12.4
Gujarat	17	39.1	54.51	0.672	0.56	90.9	71	44.2	40.3	13.2	54.9	27.2	62	18.4
Haryana	11.7	34.9	43.44	0.708	0.46	91.6	89.8	47.4	42.9	18.4	62.7	15.8	55	33.5
Himachal Pradesh	11	28.4	37.3	0.725	0.49	94.9	85.7	62.5	39.8	13	53.5	16.2	66.7	8.9
Jammu & Kashmir	14.9	15.5	47.12	0.688	0.55	89.2	79.3	41.5	40.1	12.6	54.3	12.1	61.7	10.7
Jharkhand	29.1	36.2	67.77	0.599	0.67	77.7	30	80.6	49.1	15.2	65.2	31.6	71.9	30.5
Karnataka	19.3	32.5	59.7	0.682	0.5	89.3	65.8	43.4	33	10.9	44.8	20.8	60.7	23.7
Kerala	12.6	20.5	43.09	0.779	0.44	94.3	99.2	42.3	29.5	4.4	34.2	9.7	67.6	14.5
Madhya Pradesh	19.6	39.5	55.07	0.606	0.53	84.7	42.8	69.7	39.3	12.2	52.5	28.4	60.5	31.4
Maharashtra	16.9	34.1	54.97	0.696	0.42	91.5	71.2	36	36.9	10.3	48	23.5	67.6	21.1
Manipur	6	28.9	60.17	0.696	0.52	41.6	98.7	57.6	22.1	4	26.4	8.8	77	45.5
Meghalaya	14.7	40.4	63.72	0.656	0.56	67.9	92.4	74.7	38.7	16.1	56.2	12.1	77.3	27.7
Mizoram	5.8	27.4	54.99	0.705	0.65	91.4	99.1	31.2	20.4	4.2	24.8	8.4	79	14

Continued.

					Environmental Factors				Maternal Aneamia			Maternal Factors		
State	**Child-ren with WHZ ≤2SD (%)**	**Child-ren with HAZ ≤2SD (%)**	**Propor-tion of food insecure house holds**	**Human Develop-ment Index (HDI)**	**State vulnerab-ility index (climate change)**	**HH with improved source of drinking water**	**With toilet facility**	**Using solid fuel for cooking**	**Mild**	**Moder-ate**	**Severe**	**Maternal BMI<18.5 kg/m^2**	**Women's participation in decision making**	**Domestic Violence (physical or sexual)**
Nagaland	12.9	26.2	48.02	0.679	0.44	80.6	98.3	66.6	22	5.2	27.9	12.3	90.7	15.7
Odisha	13.9	29.1	69.95	0.606	0.63	88.8	35	79.6	40.5	9.8	51	26.5	60.3	34.5
Punjab	6.7	24.3	49.81	0.723	0.47	99.1	92.9	33.5	42.3	10.8	53.5	11.7	69.6	19.2
Rajasthan	14.3	36.8	54.91	0.629	0.53	85.5	54	67.8	34.6	11.2	46.8	27	59.4	23.1
Sikkim	6.9	21.8	53.93	0.716	0.48	97.6	99.7	39.1	27.1	7.2	34.9	6.4	89.4	4.9
Tamil Nadu	20.7	19.7	46.75	0.708	0.46	90.6	61.7	24.3	39.7	14	55	14.6	68.1	45.5
Telangana	17.9	29.3	49.78	0.669	0.48	77.9	69	30.8	36.8	17.3	56.6	22.9	57.1	45.1
Tripura	12.8	31.9	59.25	0.658	0.57	87.3	97.9	62.1	42.3	11.5	54.5	19	77.5	26.8
Uttar Pradesh	18.5	38.8	62.14	0.596	0.58	96.4	45.8	66.7	38.8	12.5	52.4	25.3	59.6	34.3
Uttarakhand	5.9	29.9	53.16	0.684	0.47	92.9	82.9	48.1	33.5	10.5	45.2	18.4	72.3	13.5
West Bengal	20.1	25.3	60.41	0.641	0.59	94.6	74.9	69.6	48.9	12.8	62.5	21.3	70.8	32.6
Correlation wasting			0.3	-0.5	0.3	-0.1	-0.7	0.6	0.54	0.44	0.53	0.69	-0.35	0.37
Correlation stunting			0.6	-0.7	0.4	0.3	-0.7	0.2	0.36	0.4	0.39	0.67	-0.4	0.36

Maternal factors and childhood undernutrition

Maternal factors show a strong bearing on child nutritional status. 23% women in India have Body Mass Index (BMI) <18.5 kg/m^2. Both stunting and wasting showed strong positive correlation with low maternal BMI (r=0.7 in both cases) (Table 4). Both wasting and stunting were also positively corelated to maternal anaemia (r=0.53 for wasting and 0.39 for stunting for any form for maternal anaemia, r=0.44 for wasting and 0.40 for stunting for moderate anaemia and r=0.54 for wasting and 0.36 for stunting for mild anaemia) (Table 4). Women empowerment was a protective factor against child undernutrition (r=-0.35 for wasting and -0.40 for stunting) (Table 4). Domestic violence faced by women was positively correlated with wasting and stunting (r=0.37 for wasting and 0.36 for stunting) (Table 4).

Childhood undernutrition and HDI

HDI summarizes a country's achievement in terms of health (assessed by life expectancy at birth), knowledge (in terms of years of schooling) and standard of living measured by per capita gross national income (GNI).[13]

Table 4 also shows that both childhood wasting and stunting are negatively correlated to HDI (r=-0.50 for wasting and -0.70 for stunting).

Childhood undernutrition and food insecurity

Food insecurity was associated with both wasting and stunting; correlation coefficient (r) for wasting was 0.3 and for stunting was 0.6, indicating long term deprivation among food insecure households (Table 4).

Climate change and child undernutrition

Climate change causes disruption in livelihood and food system with a downward spiraling effect on nutrition and poverty.[14] Table 8 shows that child nutrition was positively correlated with climate change vulnerability (r=0.30 for wasting and 0.40 for stunting); implying that climate change has a potential to adversely affect nutritional outcome among children (Table 4).

DISCUSSION

Addressing undernutrition among children in a sustainable manner needs a multisectoral approach, bringing together the nutrition specific and nutrition sensitive interventions.[15] The index study reiterates the importance of evidence based key essential nutritional interventions, namely, promotion of optimal breastfeeding and complementary feeding, childhood illness prevention, addressing micronutrient deficiencies, improved water and sanitation, management of acute malnutrition and improving maternal health indicators.[16] It however also brings out the need to include parental schooling, agriculture, social safety net, mitigating adverse effects of climate change and early childhood development.

Among the essential nutritional interventions, NITI Ayog has identified improving complementary feeding as one single most intervention, with a potential to avert 60% cases of stunting among children.[17] The index study found the need to further emphasize on dietary diversity within the complementary feeding interventions.

Micronutrient deficiencies (also called hidden hunger) and undernutrition have been found to coexist, and are positively corelated. Anemia showed the strongest correlation with both forms of undernutrition. This assumes public health significance as anaemia among children below 5 years is a severe public health problem (prevalence >40%) in 10 states and of moderate public health (prevalence20-39.9%) in 16 states of India.[18] Bottlenecks related to anaemia control programmes need to be addressed. VAD, vitamin B12 and folic acid deficiencies also had a positive correlation with undernutrition. Zinc deficiency was corelated with wasting, though its association with stunting was not evident. VAD is a severe public health issue (prevalence >20%) among children below 5 years in 12 states, and moderate public health issue (prevalence 10-19.9%) in another 10 states, calling for regularisation of Vitamin A supplementation rounds.[19] Vitamin B12 and folate deficiencies are associated with anaemia, insulin resistance and adiposity.[20] Improving dietary diversity, addition of animal source food including dairy products in diets in addition to existing micronutrient supplementation program could help in addressing the twin issues of undernutrition and hidden hunger.

Illness prevention through immunization program as well as clean environmental conditions (access to improved source of drinking water and household toilet facilities) have shown negative association with undernutrition, i.e., they are protective factors. A metanalysis showed that better nutritional outcomes can be achieved by preventing infections and diarrhea through provision of clean drinking water and sanitation.[21] Studies show higher coverage is required to optimize the benefits of WASH interventions.[22]

Additionally, this study found a positive association of indoor air pollution with childhood wasting and stunting. Similar evidences of solid-fuel related indoor air pollution on childhood undernutrition and anemia and low birthweight have been documented in other studies also. This is compounded by the fact that disease burden from usage of solid fuels is higher among women and children from poorer households with low access to improved fuels.[23-28]

Maternal and childhood nutrition are inextricably linked. Both wasting and stunting showed positive correlation with maternal undernutrition and anemia, calling for attention to women's health. WHO guidelines have

enlisted recommendations for health system strengthening to improve coverage, prevention and treatment measures; these need to be adapted for a comprehensive policy for maternal health in India.[29]

Apart from maternal health positive correlation was also found between prevalence of domestic violence faced by women and childhood undernutrition. Some studies have found that women facing repeated incidences of domestic violence had a higher risk of being underweight and anemic.[30-32] Another analysis of 42 demographic and health surveys found childhood stunting and underweight to be associated with intimate partner violence.[33] Conversely, women empowerment is a protective factor against child undernutrition.

Climate change vulnerability was also found to be positively correlated with child undernutrition. Environmental consequences of climate change include increased temperature, excess precipitation in some areas and droughts in others, extreme weather events, and increased sea level. These consequences adversely affect agricultural production, access to safe water, and worker productivity, and, by inundating land or making land uninhabitable and uncultivatable, resulting in spike in food prices while simultaneously lowering household income.[34,35] It is projected that due to climate change, calorie availability and availability of nutritious food would be reduced which, with concomitant rise in infectious diseases and micronutrient deficiencies, will negate the improvements achieved in childhood nutritional status.[36] South Asia is projected to be particularly hard hit due to climate change.[37] Evidence points towards disproportionate impact of the crisis on the poorest populations.[38,39] All Indian States were vulnerable to climate change in varying degrees. States need to improve the adaptive capacities in face of climate change by increasing share of horticulture in agriculture, area covered under crop insurance, forest area per 1000 rural population, women's participation in workforce, rural employment guarantee scheme, road and rail connectivity, density of health care workers (access to functional health care).[40]

Food insecurity is positively corelated with under-nutrition. Government of India, through enactment of NFSA 2013, gives legal food security entitlement to vulnerable population groups. While Midday meals and supplementary nutrition provision through Integrated Child Development Scheme (ICDS) have universal coverage, subsidized provision of food grains through public distribution system are aimed to cover 75% of the rural and 50% of urban population. Further MNREGA assures at least 100 days of work in a year. Investment is needed in such social safety nets. India has successfully reduced the proportion of population living below poverty line between 1990 and 2011-12 and increased life expectancy by nearly 11 years and almost 4.7 years of additional expected years of schooling. The per capita GNI also saw an increase of 266.6% in this period. However large inequalities persist causing 28% loss to HDI values.[41,42] Negative correlation with wasting and stunting implies that to address childhood undernutrition, governments must also strive to improve health and well-being, years of schooling and per capita GNI, with strong gender and equity focus.

The present analyses used the secondary data from different sources and tried to establish the association between childhood undernutrition and other nutritional and macro level development indicators. The limitation of the study is that, these secondary data was collected and published by different agencies with different purposes and may not be for showing such associations. A primary study with clearly stated objective and robust study design of showing the relationship between childhood undernutrition and these parameters would be helpful to establish causal relationship between them.

CONCLUSION

In the nutshell, India needs continued strong leadership, adequate financing, uninterrupted universal coverage and a synergetic combination of strategies that bring together essential nutritional interventions and those that address underlying and basic causes are required to sustainably address childhood undernutrition in India. The present analyses help the policy makers and program implementers to see the childhood undernutrition problem from a wider lens and address different underlying factors to bring sustainable change in childhood nutritional outcomes.

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