Ecosystem Determinants of Height and Weight Among Poverty Ridden Children in India

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Abstract

The 2020 Global Nutrition Report by UNICEF highlights the high rate of deaths among children under five years of age, with India being one of the top five countries. Studies suggest that more than half of these early child deaths were attributable to health issues associated with malnutrition, particularly in the case of countries with extreme poverty, scarcity of essential resources, lack of access to appropriate healthcare, and wide disparities of wealth. We situated our analysis on the lines of Bronfenbrenner's ecological systems theory and interpreted the results through the lens of this theory.Observations from 70618 children between ages of 2-5 years old, from poverty ridden communities in India, were used. The poverty ridden households contain poorer and poorest populations classified by DHS based on wealth index. Three measures, namely, stunted, wasted, underweight and overweight were calculated according to WHO child growth standards, and used as dependent variables. The independent variables include child's biological characteristics, health status, dietary adequacy. We also analyzed the role of maternal factors such as mother's anthropometry, health status, education, access to healthcare facilities. In addition, the variables include home environmental conditions, social welfare systems and geographical location. Binary Logistic Regression model two sets of Multinomial Logistic regression models were developed for the analyses. We found that a child's health, particularly anaemia levels, vaccination and multivitamin access play a vital role in influencing a child's anthropometric measurements. Moreover, dietary diversity has a crucial role to play in forming a child's height and weight. Finally, we conclude that maternal factors including health status (anaemia levels and anthropometric measurements) and access to healthcare facilities significantly influence a child's likelihood to experience malnutrition. Three levels, namely, microsystem, mesosystem and exosystem of the Bronfenbrenner's ecological systems theory emerge as most significant contributors to the likelihood of malnutrition. Implications for policymakers include importance of access to healthcare as basic determinant of child well-being can help mothers to maintain and improve their health status and prevent the health issues which has direct impact on likelihood of children malnutrition.

Keywords

Access to healthcare; Awareness of ICDS program; Bronfenbrenner ecological systems theory; Poverty ridden children; Nutritional factors.

1. Introduction

Children are full of energy, ideas, and hope for the future. However, the Global Nutrition Report reveals that high rates of deaths among children under 5 years are being reported all over the world (UNICEF, 2018). Further, a majority of these deaths is attributable to malnutrition and its associated diseases, which are preventable with simple and affordable interventions (Rice *et al.*, 2000; Bryce *et al.*, 2005; UNICEF, 2020). Child malnutrition, like many other health outcomes, is a multifaceted problem appear in triple burden namely undernutrition, micronutrient deficiencies/hidden hunger, and overweight or/and obesity (UNICEF, 2016). Malnutrition in its all forms primarily

occurs due to the lack of nutritional adequacy in terms of limited or absence of consumption of diverse nutrients on a regular basis, characterized as imbalanced or bulky diet (ChildrenforHealth, 2021; Ananya Mandal, 2019; WHO, 2020b).

Malnutrition is regarded as one of the major impediments to child well-being affecting all areas of a child's physical and mental health, body immunity, overall growth, and development (WHO, 2005; Ijarotimi, 2013). Evidence shows that malnutrition is significantly associated with poverty and radically unequal distributions of income and assets, within and across countries (Christensen, 2009). Poverty leads to unfavourable conditions and adverse influence on social determinants of health which results in experiencing unreliable food supply and further, contributes to the problem of malnutrition (Lee *et al.*, 2020). The adverse consequences of malnutrition on health status of children compel us to understand the major factors contributing to malnutrition and its associated diseases particularly in poverty ridden communities with a higher prevalence of malnutrition.

Among other nations worldwide, India contributes the highest number of child deaths under five years of age (EconomicTimes, 2019; UNICEF, 2019b). Existing evidence highlights a myriad of factors associated with malnutrition and its associated diseases. Among others, factors such as lack of access to proper medical and health care facilities for children and mothers, lack of sanitation and hygienic living environment, mother's lack of education and large economic disparities are top risk factors responsible to aggravate the risk of the nutritional deficiency and further, the prevalence of malnutrition and its associated diseases in children (Adarsh, 2020; Singh, 2020b; UNICEF, 2021). Consequently, disparities in access to the healthcare facilities, maternal education, and environmental conditions remain major challenges in India.

Although the number of nutrition and health interventions including dietary diversification, food supplements, food fortification, and biofortifications (Jha and Warkentin, 2020) have been employed to help individuals to change diets towards consuming nutritious diets and provided proper nutrition to children and women (Maurya and Kushwaha, 2018), in India, studies have reported a comprehensive assessment of the ecosystems variables leading to the prevalence of malnutrition remains limited. Besides, the latest national data available on nutritional health status in India suggests the incidence of the burden of malnutrition among children has reduced rather slowly and not commensurate to the country's economic growth in the last decade (Singh, 2020a).

Hence, a relook at the relevant system variables leading to a negative impact on height and weight, particularly in the context of poverty ridden communities with higher prevalence of malnutrition, becomes an urgent imperative. The current study attempts to address this gap and contribute to more effective approaches in saving vulnerable children's lives from malnutrition.

The Bronfenbrenner's ecological systems theory (Bronfenbrenner, 1979) forms the foundational context for the analysis. The theory moves beyond food to identify factors at various environmental levels putting children at higher risk of reduced growth and malnutrition. According to Bronfenbrenner (Bronfenbrenner, 1979), a child' surrounding environment plays a significant role in physical growth and further, shaping up a child's nutritional health status (Schell, Gallo and Ravenscroft, 2009; Zhoua and Cheah, 2016).

A look at the height and weight parameters of 70618 poverty ridden children from the DHS survey demonstrates approximately 40% as stunted in height, 35% underweight and 25% not meeting their height to weight ratio (Table 1). The data reveals the significant prevalence of undernutrition in terms of stunted, wasted, and underweight among the poverty ridden children. With this preliminary data analysis, we defined our objectives.

Table 1. DHS survey height and weight distribution of poverty ridden children

Height for age (HAZ)			Weight for height (WHZ)			Weight for age (WAZ)		
	Count	Percentage		Count	Percentage		Count	Percentage
Stunted	27834	39.4%	Wasted	11859	16.8%	Underweight	24839	35.2%
Normal	42784	60.6%	Overweight	5208	7.4%	Overweight	4652	6.6%
			Normal	53551	75.8%	Normal	41127	58.2%

1.1 Objectives

While several studies highlight the general nutritional determinants, existing literature lacks an empirical investigation on determine the ecosystem and nutritional factors influencing the height and weight of poverty ridden children in India. This study attempts to address this gap and specifically explore the influence of environmental factors on the nutritional health status of a child, in the context of India.

The paper contains six sections. Section 2 presents the literature review. Section 3 explains the method used for analysis, including the theoretical foundation and data analyses. Section 4 presents the results of the analyses, followed by a discussion on the key findings in Section 5. Section 6 presents the conclusion and implications derived from the study.

2. Literature Review

According to the Food and Agriculture Organization of the United Nations (FAO) and the International Policy Centre for Inclusive Growth (IPC-IG), poverty and malnutrition remain as greatest challenges for countries (IPC-IG and FAO, 2020). In addition, the 2020'State of Food Security and Nutrition has reported that 60 million people have been affected by hunger, and hunger numbers trending upward since 2014 (Khiem Nguyen, 2020). Hunger is mainly caused by poverty and radically unequal distributions of income and assets, within and across countries (Christensen, 2009). People due to the insufficient food intake often experience hunger, and over the long period of time due to the lack of nutritious diet for maintaining the health and development this condition could leads to malnutrition. Malnutrition affects people of every age, although infants, children, and teens may suffer the most because many nutrients are critical for normal growth and development.

2.1 Malnutrition and health hazards

Malnutrition forms a key contributor to child morbidity and mortality worldwide (FAO, 2018; WHO, 2019b). The Global Nutritional Report by WHO has been estimated, approximately 45% of deaths among children under five years age are linked to undernutrition (WHO, 2019a), majorly due to the insufficient or lack of access to the essential nutritious foods (HINDRISE, 2021). At the same time, evidence shows the overconsumption of processes food, refined carbohydrates, added sugar, fats, oil, animal-sources foods and nutrition transition (shirt in dietary patterns) are the leading causes of 38.2 million overweight and/or obese among children under five years age (Popkin, Adair and Ng, 2012; WHO, 2021b, 2021c). Besides, studies reveals as consequences of diets with low variety, in particular, low in iron, vitamin A and iodine, globally half of children under five years age affect up by micronutrients deficiencies or hidden hunger (deficiency of vitamin and minerals) (UNICEF, 2019a; WHO, 2021a).

Malnutrition is mainly attributed to the deficiency in one or more of the three basic prerequisites for adequate nutrition: food, health, and care. As a result, malnutrition is regarded as one of the major impediments to human well-being affecting all areas of a child's health, growth and development (Mwaniki EW, 2013; Chinyoka, 2016).

Malnutrition, specifically undernutrition, is regarded as one of the most significant health issues in developing countries including India. Undernutrition negatively impacts the physical health of children including being overall undernourished (low weight for age), too thin/wasted (low weight for height) or too short/stunted (low height for age) (Maleta, 2006; UNICEF, 2007). Moreover, undernutrition tends to expose children to a higher risk of mental illness which can result in mental retardation, severe mental illness, poor mental development and school achievement as well as behavioural abnormalities (Martins *et al.*, 2011). Consequently, undernutrition has adverse impacts on educational performance, economic productivity and reproductive outcomes in adulthood (Stewart *et al.*, 2013). Furthermore, undernutrition leads to the reduction of a child's immunity to diseases such as diarrhoea, pneumonia, measles, malaria among others, and infections such as acute respiratory infection (ARI) that directly influences the child's nutritional health status, in turn reduce and deprive the body from essential nutrients (Olaf Müller, 2016; Singh, 2020a).

These adverse effects of malnutrition on child health compel us to understand the health and nutritional factors leading to malnutrition in children surrounding environment. Extant literature suggests myriads of factors that might affect a child's overall health, growth and progress and leads to malnutrition, which we review further in this section.

2.2 Factors Causing Malnutrition

Like other health outcomes, children malnutrition is a multidimensional problem resulting from a complex combination of sociodemographic, socioeconomic, sociocultural factors. Moreover, several studies highlighted factors such as government policies and political commitment, media and social media, which affects the children nutritional health status.

2.3 Sociodemographic *Factors:*

Several studies have inferred the significant association between child socio demographic factors and health status. These socio demographic factors such as sex, age, residence, individual, environment, family and religion strongly influence the physical development among children. In addition to the health status, socio demographic factors in the marginalized regions are key determinants of the likelihood of child malnutrition (Franchetti and Ide, 2014; Chaudhary and Agrawal, 2019). Socio Demographic factors matter because the circumstances in which children are born and grow up can strongly influence on their overall health, growth and well-being.

2.4 Socioeconomic Factors:

Extant literature highlights the low socioeconomic status and poverty as key factors leading malnutrition in children, particularly in low socioeconomic communities in developing countries (Galgamuwa et al., 2017; Schroeder and Brown, 1994). Socioeconomic factors, including dwelling, employment, income, and wealth status of parents or caretaker, significantly affect a child's nutritional health status. In addition, factors such as: low literacy rate, social discrimination, gender inequality and social influences (including physical aggression, sexual coercion, verbal abuse and controlling behaviour) have an influence on a child's nutritional health. People with lower socioeconomic status are most vulnerable to food insecurity since purchasing power is a main determinant of the ability to afford nutritious and diversity food choices (Thompson *et al.*, 2017).

Poverty is a multidimensional concept which is both a cause and consequence of malnutrition in all forms particularly undernutrition (Vorster and Kruger, 2007). Previous studies positively relate poverty with child malnutrition. The reason rooted in the fact that an influence of poverty on household food insecurity, inadequate care and unhealthy household environment, and lack of health care services factors. These factors lead to poor nutrition of a child and hence increase the possibility of malnutrition in a child, particularly in developing countries (Reinhardt and Fanzo, 2014).

Numerous reports provided evidence on the socioeconomic determinants of child health outcomes in low income countries (Barros *et al.*, 2010). Moreover, these studies inferred those children from the underprivileged backgrounds or low socio-economic status, were found to be exposed to greater risk of suffering from malnutrition. Consequently, policymakers should deliberate a plan on how to deliver necessary resources to such populations by collecting more evidence on the profile of undernourished children in low-income countries.

2.5 Maternal factors:

Studies demonstrate that maternal factor including (1) mother's physical health such as anthropometric measurements of height and weight and obstetric history (e.g., birth weight, birth order), (2) mother's mental health status such as marital status or age at marriage, (3) education level (e.g., Primary, secondary, and higher), general knowledge regarding childhood illness and adequate nutrition and feeding, care and hygienic practices related to child, (4) access to healthcare facilities (e.g. access to prenatal and postnatal care) (Afsharinia *et al.*, 2021).

2.6 Access to the healthcare:

Existing evidence shows that particularly in the context of India with rapid growing rates of prevalence of malnutrition and its associated diseases, there exist significant barriers to access health care services, particularly for women. These barriers include maternal problem with access to the health care facilities rooted in gender discrimination such as a woman is enforced to ask permission or ask money from husband to go for health care facilities for herself or for her child (Moradhvaj and Saikia, 2019), these barriers are even more prominent in rural areas (Shin and Kim, 2010). Inaccessibility to health care facilities due to these barriers pose a significant challenge among Indian children in terms of increased risk of poor health status of a child due to inadequate and absence of timely care or delayed treatment. This might result in poor nutritional health or even mortality (Källander *et al.*, 2008). Particularly, children with prolonged and chronic diseases are more vulnerable to higher risk of malnutrition prevalence due to nutritional derangements (Diamanti *et al.*, 2019).

2.7 Environmental Factors:

Unfavourable environmental factors may augment the exposure of children to the risk of an infectious disease which could significantly affect the growth and well-being of a child that in turn may lead to malnutrition. Environmental factors primarily include general environmental condition of a child such as Water, Sanitation, Hygiene (WASH) infrastructure and services (WORLD BANK, 2017; WHO, UNICEF, 2015). Poor WASH conditions lead to several infectious diseases which significantly affect the nutritional status of a child. In addition, previous studies have identified factors like housing characteristics (safety housing, type of construction, building material and, Indoor plumbing, crowding conditions, toilet facilities and sewerage system), living status (home atmosphere, feeding atmosphere) among others to be significantly associated with undernutrition of a child (Chopra, 2003; Hussein, 2016; Jain et al., 2018; Krieger and Higgins, 2002; Maleta, 2006; Reyes et al., 2004; Stewart et al., 2013). Furthermore, climate change including extreme weather events, droughts, floods, natural and manmade disasters, shifts in agriculture, soil infertility etc., is one of the major factors that indirectly affects a child's nutrition in terms of food insecurity and food unavailability (FAO, 2008, 2017; Tirivangasi, 2017).

2.8 Religion and Sociocultural Factors:

Extant research reveals the influence of caste, ethnic, certain social and religious background on the prevalence of malnutrition in children. These group-specific or religion factors generally relate to the discrimination that these communities face in accessing income earning assets, education and government schemes providing services like food and health (Agadjanian and Jansen, 2018; Panda *et al.*, 2020). Thus, religion often influences them through the social and cultural institutions in which they participate (UNICEF, 2011).

Sociocultural factors are deeply rooted in the way of life through the culture of an individual, a group and a nation. Malnutrition could result due to the cultural and traditional practices that consequently, certain cultural groups could be associated to greater malnutrition rates compared to the other ethnic backgrounds. Sociocultural factors may reflect lack of knowledge (ignorance) on the part of child caregivers (parental and non-parental) on the dangers of their attitudes. Most of the reasons for improper food choices deeply rooted in norms, habits and beliefs which form a part of the culture in which the individual is reared which unfortunately, tend to be strongly resistant to change (Makadia *et al.*, 2017; de Almeida, Recine and Fagundes, 2019).

3. Methods

In order to investigate the factors influencing the nutritional health status of children (in terms of anthropometric measurements of height and weight) in India, data from the Indian Demographic and Health Survey (DHS) were utilized. The DHS is a national population-based survey. The data set from the DHS includes key information regarding children's health, nutrition, and demographic indicators including household, maternal characteristics, socioeconomic, environmental conditions, and region of the country, among others. The study is designed to explore the relationship between anthropometric measurements and ecosystem variables of economically vulnerable children. This dataset has one record for every child of interviewed women, born in the five years preceding the survey. We gathered observations of 1340 variables for 2.5 lakhs children, from the DHS data set. Out of the 1340 variables in the data set we have shortlisted 27 variables as relevant for the study. We have removed the rows involving data of children who were not alive at the time of the survey. The missing values were handled based on the DHS guidelines wherever available and predictive mean matching. In total, the DHS survey comprised n = 1,40,471 children 2-5 years old (after n = 25,96,27 records from children under 5 years old). In the final analysis, we extracted data for poverty ridden children (poorer and poorest groups based on DHS wealth index classification) constituting observations on 27 variables for 70,618 children in the age range of 2-5 years.

3.1 Measures - Dependent variables

Three anthropometric failure outcomes were constructed based on the WHO child growth standards (WHO, 2009), we measure height-for-age (HAZ), weight-for-height (WHZ), and weight for age (WAZ), and further classify the data set into the following categories:

- Stunting: height-for-age *z* score less than −2 standard deviations (SDs).
- Wasting and overweight: 1) wasting: weight-for-height *z* score less than −2 SDs, 2) overweight: weight-for-height z-score above plus 2 (+2.0) SDs or above the mean on the WHO Child Growth Standards.
- Underweight and overweight for age: 1) underweight: weight-for-age z-score below minus 2 (-2.0) SDs below the mean on the WHO Child Growth Standards, 2) overweight for age: weight-for-age z-score above plus 2 (+2.0) SDs or above the mean on the WHO Child Growth Standards.

3.2 Measures – Independent variables

Bronfenbrenner's ecological systems theory

Bronfenbrenner's ecological systems theory forms the base to understand and organize the ecosystem variables. The theory divided the child's environment into five nested levels, namely, the microsystem, the mesosystem, the exosystem, the macrosystem, and the chronosystem.

The microsystem level refers to the direct and strongest contact of a child including family, school, and care center. Factors like maternal health and nutritional status, pregnancy nutritional health of the mother and postnatal care of the child reflect the system. Additionally, the general home conditions on water, sanitation, hygiene (WASH) (Van Cooten *et al.*, 2019), and housing condition directly impact child health as well (Saaka and Osman, 2013).

Mesosystem describes the connection between microsystem factors. In other words, the interrelationship between two or more individuals in the microsystem influencing a child' growth become significant at this level. The variables include interaction between parents and healthcare facilities, access to the healthcare facilities (Haque *et al.*, 2020), mother's anthropometric (Sen, Roy and Mondal, 2009).

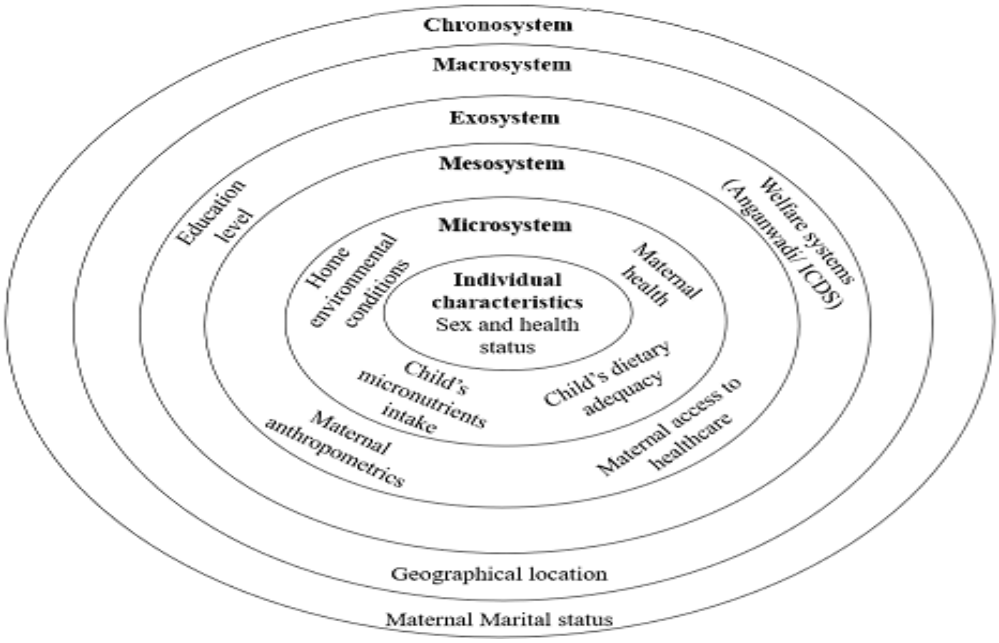

Figure 1. The Ecosystem based placing of the variables

The third level of the system, the exosystem, explains the linked among social settings. The variables of the exosystem may not interact with the child directly but strongly influence one or more microsystem structures and thus, indirectly effect the child's development. The exosystem level highlights the importance of community support such as education, health, nutritional programs, and services for child care activities (Sachdev and Dasgupta, 2001). These become more critical for poverty ridden children who face significant inaccessibility to primary education, and food insecurity.

Macrosystem, the fourth level, looks at the influence of cultural elements such as socioeconomic status, poverty, wealth, and geographic location on a child's development. Geographical location (for example, rural versus urban; hills versus plains) (Smith, Ruel and Ndiaye, 2005), socioeconomic status (for example, low income, low education and social underprivilege) (Galgamuwa *et al.*, 2017) and cultural effects (for example undervaluation of female child, and status of parents in the family) (WHO and UNICEF, 1987) impact child development.

Lastly, the chronosystem level refers to all the environmental changes across the childhood growth period (Olivia Guy-Evans, 2020). The chronosystem environmental level includes the life transition occurring over the lifetime such

as parents' marital status, financial status, parental healthcare challenges and hardship of single parenting (Scharte and Bolte, 2013) which can lead to insufficient care and higher vulnerability towards physical and mental problems (El-Sheikh *et al.*, 2008).

The independent variables categorized as per the theory in Figure 1 are listed in Table 2.

Table 2.Independent variables

Environmental levels	Independent variables		Nature of variables
Individual characteristics (e.g., sex, health, etc.)	Child's biological characteristics	Sex of child	Categorical
	Child's health status	Health problems (Fever, diarrhoea, cough)	Categorical
		Child's Anaemia level	Categorical
Microsystem (e.g., family, parents, and immediate environment)	Maternal health status	Maternal Anaemia level	Categorical
	Child's dietary adequacy	DDS	Numerical
	Child's micronutrients intake	Vitamin A in last 6 months	Categorical
		Taking iron pills sprinkles or syrup	Categorical
	Home environmental conditions	Source of drinking water	Categorical
		Housing contraction materials (Floor, roof, wall)	Categorical
Mesosystem (e.g., relationship among microsystem structures such as parents and health center)	Maternal anthropometric	Weight and height	Numerical
	Access to healthcare facilities	Maternal problem with access to healthcare	Categorical
		Number of antenatal visits	Numerical
		Baby postnatal check-up	Categorical
		Received Polio vaccinate (all doses)	Categorical
		Received DPT vaccinate (all doses)	Categorical
Exosystem (e.g., parents experience effect on a child experience)	Welfare systems (Anganwadi/ICDS)	Anganwadi benefits during pregnancy	Categorical
		Child received benefits from Anganwadi ICDS center	Categorical
		Mother received benefits while breastfeeding from Anganwadi ICDS Centre	Categorical
	Education	Maternal education level	Categorical
Macrosystem (e.g., geographic location and wealth status)	Location	Type of place of residence	Categorical
Chronosystem (e.g., life transition such as parents' divorce)	Maternal life transition	Current marital status	Categorical

3.3 Data Analysis

All analyses were performed in SPSS 20 software. Binary logistic regression and Multinomial logistic regression models were performed to evaluate the association between the dependent and independent variables. Binary Logistic Regression model probes the influence of independent variables on height for age as binary logistical regression holds two discrete categories (Stunted - 0 and Normal – 1). Multinomial Logistic Regression models probe the influence of independent variables on the two dependent variables of weight for height and weight for age. Multinomial logistic regression is applicable here as both the dependent variables hold three discrete categories. In both the multinomial logistic regression models the category "Normal" is included as the reference category for the dependent variable. Table 3 provides the descriptive analysis of the data.

4. Results

Maternal and child characteristics are shown in Table 3. About 52% of children were male (n = 36869), and 48 percent were female (n = 33749). 23% wasted children faced health problems like fever, diarrhoea, and cough. In addition, around 28 % stunted children, 25% wasted children, 28 % underweight children, and 16 % overweight children were anaemic at moderate or severe levels. Further, mothers of 85 % stunted, 83 % wasted, and 85% underweight children faced problems with accessing healthcare. 75% and 67% of children had taken DPT and polio vaccine respectively. Furthermore, close to 27% children did not consume all the major food groups like cereals/roots, vegetables, fruits, legumes/lentils, meat/fish/egg, and milk/dairy products (DDS ranges from 0 to 6). Lastly, close to 76% of malnourished children were living in rural areas.

Table 3. Descriptive statistics

	Height for age		**Weight for height**		**Weight for age**		
Variables Characteristics	**Stunted**	**Normal**	**Wasted**	**Normal**	**Underweight**	**Overweight**	**Normal**
	(n = 27834)	(n = 42784)	(n = 11859)	(n = 53551)	(n = 24839)	(n = 4652)	(n = 41127)
Sex of child							
Male	51.90	52.40	52.20	52.20	51.80	53.20	52.30
Female	48.10	47.60	47.80	47.80	48.20	46.80	47.70
Health problems (fever, diarrhoea, cough)- Yes	21.80	21.90	23.00	21.60	22.10	22.20	21.70
Faced problem with access to healthcare	85.10	78.40	83.10	80.70	85.00	80.20	78.70
Taken Polio vaccination	66.90	69.00	68.20	68.80	67.20	60.80	69.60
Taken DPT vaccination	74.20	78.10	77.70	76.70	75.30	71.00	77.90
Child's anaemia level							
Severe	1.70	0.80	1.20	1.20	1.70	1.00	0.90
Moderate	28.10	18.80	24.50	22.60	27.80	15.90	20.00
Not Anaemic	42.50	55.50	44.00	50.50	41.80	66.60	53.70
Dietary Diversity of the child							
Consumption of none (0) of the major food groups	31.20	28.40	29.20	29.80	30.90	26.80	29.00
Consumption of one major food group	19.90	19.70	20.00	19.90	19.90	18.90	19.90
Consumption of two major food group	17.90	19.30	18.80	18.60	18.20	19.60	19.00
Consumption of three major food group	14.00	14.70	14.50	14.30	14.00	15.40	14.60
Consumption of four major food group	9.00	9.40	9.20	9.20	9.10	10.30	9.20
Consumption of five major food group	4.70	5.00	4.80	4.90	4.70	5.20	5.00
Consumption of six major food group	3.30	3.40	3.50	3.30	3.20	3.60	3.40
Type of place of residence							
Urban	23.80	23.50	23.20	23.80	23.80	22.40	23.70
Rural	76.20	76.50	76.80	76.20	76.20	77.60	76.30

Table 4 illustrates the results of the regression models. The table describes the logarithmic association between the stunted, wasted, underweight and overweight growth of children and factors contributing to the likelihood of impaired growth.

Table 4. Regression Analysis

Variables of Interest	Height for age			Weight for height			Weight for age					
	STUNTED			WASTED			UNDERWEIGHT			OVERWEIGHT		
	B	Exp (B)	95% CI for EXP (B)	B	Exp (B)	95% CI for EXP (B)	B	Exp (B)	95% CI for EXP (B)	B	Exp (B)	95% CI for EXP (B)
Child's Individual characteristics												
Sex of child (Male - Female [a])	0.023	1.02	0.99−1.05	0.002	1.00	0.96−1.04	-0.022	0.98	0.94−1.01	0.031	1.03	0.97−1.09
Health problems (fever, diarrhoea, cough) (No - Yes [a])	0.005	1.01	0.96−1.04	-0.070***	0.93	0.88−0.97	-0.030	0.97	0.93−1.00	-0.014	0.99	0.91−1.06
Child's anaemia level (Severe-Not anaemic [a])	-1.025***	0.36	0.31−0.41	0.180**	1.20	0.99−1.43	0.832***	2.30	1.98−2.66	-0.065	0.94	0.68−1.28
Child's anaemia level (Moderate-Not anaemic [a])	-0.610***	0.54	0.52−0.56	0.183***	1.20	1.14−1.26	0.491***	1.64	1.56−1.70	-0.338***	0.71	0.65−0.77
Child's anaemia level (Mild - Not anaemic [a])	-0.328***	0.72	0.69−0.74	0.277***	1.32	0.99−1.08	0.303***	1.35	1.30−1.40	-0.493***	0.61	0.56−0.66
Microsystem environmental level												
Maternal anaemia level (Severe - Not anaemic [a])	-0.070**	0.93	0.79−1.08	-0.065	0.94	0.76−1.14	0.080	1.08	0.92−1.26	0.130	1.14	0.83−1.55
Maternal anaemia level (Moderate-Not anaemic [a])	-0.088***	0.92	0.92−0.99	-0.020	0.98	0.92−1.04	0.121***	1.13	1.07−1.18	0.045	1.05	0.94−1.15
Maternal anaemia level (Mild - Not anaemic [a])	-0.041**	0.96	0.87−0.96	0.038**	1.04	0.99−1.08	0.078***	1.08	1.04−1.12	-0.038	0.96	0.90−1.03
DDS	0.010**	1.01	1.00−1.01	0.009	1.01	0.99−1.02	-0.003	1.00	0.98−1.00	0.040***	1.04	1.02−1.06
Vitamin A in last 6 months (No - Yes [a])	0.005	1.01	0.97−1.04	-0.015	0.99	0.94−1.03	-0.002	1.00	0.96−1.03	-0.028	0.97	0.90−1.04
Taking iron pills sprinkles/syrup (No-Yes [a])	-0.093***	0.91	0.87−0.95	-0.117***	0.89	0.84−0.93	0.001	1.00	0.95−1.04	-0.177***	0.84	0.77−0.90
Source of drinking water (Piped water - Water from spring [a])	-0.002	1.00	0.93−1.06	0.044	1.05	0.96−1.13	0.024	1.02	0.96−1.09	0.014	1.02	0.89−1.14
Source of drinking water (Dug well - Water from spring [a])	< 0.01	1.00	0.93−1.06	0.053	1.05	0.97−1.14	0.013	1.01	0.95−1.08	-0.032	0.97	0.85−1.09
Main floor material (Natural floor - Finished floor [a])	0.037**	1.04	0.99−1.08	-0.022	0.98	0.92−1.03	-0.040**	0.96	0.92−1.00	0.034	1.04	0.95−1.12
Main floor material (Rudimentary floor - Finished floor [a])	-0.004	1.00	0.93−1.06	-0.036	0.96	0.88−1.04	-0.016	0.98	0.91−1.05	-0.093	0.91	0.79−1.04
Main wall material (Natural walls - Finished walls [a])	-0.044**	0.96	0.91−1.00	-0.034	0.97	0.91−1.02	0.020	1.02	0.91−1.05	-0.021	0.98	0.89−1.07
Main wall material (Rudimentary walls - Finished walls [a])	-0.047**	0.95	0.90−1.00	-0.024	0.98	0.91−1.04	0.036	1.04	0.98−1.09	-0.022	0.98	0.88−1.08
Main roof material (Natural roofing - Finished roofing [a])	-0.009	0.99	0.93−1.05	0.085**	1.09	1.00−1.17	0.012	1.01	0.95−1.07	0.030	1.03	0.91−1.16
Main roof material (Rudimentary roofing - Finished roofing [a])	-0.035	0.97	0.89−1.03	-0.027	0.97	0.88−1.06	-0.038	0.96	0.89−1.03	-0.114	0.89	0.77−1.03
Mesosystem environmental level												
Maternal weight (kg)	< 0.01***	1.00	1.00−1.00	< 0.01***	1.00	1.00−1.00	< 0.01***	1.00	1.00−1.00	-0.001***	1.00	0.99−1.00
Maternal height (cm)	0.007***	1.01	1.00−1.00	< 0.01	1.00	1.00−1.00	-0.005***	1.00	0.99−0.99	-0.002***	1.00	0.99−0.99
Problem with access to healthcare (No –Yes [a])	0.265***	1.30	1.24−1.35	-0.099***	0.91	0.85−0.95	-0.223***	0.80	0.76−0.83	-0.133***	0.88	0.80−0.94
Number of antenatal visits during pregnancy	0.020***	1.02	1.01−1.02	-0.002	1.00	0.99−1.00	-0.014***	0.99	0.98−0.99	0.008**	1.01	1.00−1.01
Baby postnatal check-up within 2 months	-0.025	0.14	0.94−1.00	-0.025	0.98	0.93−1.01	0.013	1.01	0.97−1.04	0.104***	1.11	1.03−1.18

Polio (No - Yes [a])	0.022	1.02	0.98−1.06	0.058**	1.06	1.00−1.11	0.037**	1.04	0.99−1.08	0.258***	1.29	1.20−1.39
DPT (No - Yes [a])	-0.153***	0.86	0.82−0.89	-0.088***	0.92	0.86−0.96	0.050**	1.05	1.00−1.09	0.201***	1.22	1.12−1.32
Exosystem environmental level												
During pregnancy benefited from Anganwadi/ ICDS centre (No - Yes [a])	-0.001	1.00	0.95−1.04	0.043	1.04	0.98−1.11	0.027	1.03	0.97−1.08	0.079	1.08	0.98−1.19
Child benefited from Anganwadi/ICDS centre (No - Yes [a])	-0.027	0.97	0.93−1.01	-0.015	0.99	0.93−1.03	-0.014	0.99	0.94−1.02	-0.074**	0.93	0.85−1.00
While breastfeeding benefited from Anganwadi/ICDS centre (No - Yes [a])	0.044**	1.05	0.99−1.09	-0.035	0.97	0.90−1.02	-0.064**	0.94	0.89−0.98	0.006	1.01	0.91−1.10
Educational level (No education – Higher [a])	0.012	0.60	0.95−1.07	-0.025	0.98	0.89−1.05	-0.015	0.99	0.92−1.05	-0.032	0.97	0.85−1.09
Educational level (Primary -Higher [a])	0.014	0.72	0.94−1.08	-0.034	0.97	0.88−1.05	-0.006	1.00	0.92−1.06	-0.008	0.99	0.86−1.13
Educational level (Secondary-Higher [a])	0.014	0.69	0.94−1.08	0.037	1.04	0.96−1.11	-0.005	1.00	0.93−1.05	-0.043	0.96	0.85−1.07
Macrosystem environmental level												
Type of residency (Urban - Rural [a])	-0.005	1.00	0.95−1.03	-0.051**	0.95	0.90−1.00	0.002	1.00	0.96−1.04	-0.087**	0.92	0.84−0.99
Chronosystem environmental level												
Marital status (Formally married -Divorced [a])	0.012	1.01	0.79−1.28	0.274	1.19	0.60−2.34	0.107	1.29	0.76−2.17	-0.136	0.98	0.38−2.46
Marital status (Not formally married-Divorced [a])	-0.087	0.92	0.68−1.22	0.404**	1.50	1.01−2.21	0.151	1.11	0.85−1.57	-0.338	0.71	0.40−1.25
Marital status (Widowed - Divorced [a])	-0.072	0.93	0.59−1.44	-0.365	0.69	0.35−1.37	-0.168	0.85	0.52−1.35	-0.615	0.54	0.22−1.33

a Represents reference level; CI indicates confidence interval; Significance determined at p <0.1; ***p<0.01, **p<0.05, *p<0.1.

5. Discussion

5.1 Factors influencing stunted growth of children

Three factors stand out as significant for stunted growth of children, the child's health/nutritional status, maternal health status, access to health facilities, and lactating mothers who receive benefits from Anganwadi/ICDS canter. In general, the results brought out three environmental levels of Bronfenbrenner's ecological systems theory, namely, microsystem, mesosystem, and exosystem as influencing the likelihood of a child's stunted growth.

The health status of a child in terms of anaemia at all levels (mild, moderate, and severe) emerges as a strong influence on stunted growth. Anaemia refers to fewer red blood cell count in the body (Cleveland Clinic, 2021), slowing the metabolism by inhibiting oxygen flow to muscles and tissues (El-Khuffash and Afif, 2017; Harvard T.H. Chan, 2021). This in turn decrease the muscular strength and result in growth retardation or stunted growth (Soliman, De Sanctis and Kalra, 2014).

Moreover, the results show that the likelihood of a child having normal linear growth (height for age) increases with an increase in dietary diversity score (DDS). DDS reflects consumption of diverse nutrients, and measures the nutritional adequacy in a child's diet (Steyn *et al.*, 2006), consequently impacts the likelihood of a child's normal linear growth (Dinku, Mekonnen and Adilu, 2020). Dietary Diversity Score (DDS) gets calculated by taking the nutritional variables and summing the number of times a unique food group gets consumed during the last 24 hours (Rathnayake, Madushani and Silva, 2012). Food groups under consideration to calculate DDS were cereals/roots, vegetables, fruits, legumes/lentils, meat/fish/egg and milk/dairy products.

Results show positive impact of iron supplements on a child's healthy growth. Its absence from the diet can lead to anaemia, and anaemia deprives the body from proper weight gain. Our results on iron consumption confirm the same. The poverty ridden communities face limited accessibility to iron supplements thereby increasing the likelihood of stunted growth in children.

Maternal anaemia level (severe, moderate, and mild) increases the likelihood of a child's stunted growth. Evidence shows maternal anaemia level associated with poor birth outcomes such as low birth weight, prematurity of the child, and limited foetal iron store (Abu-Ouf and Jan, 2015). Furthermore, a child's early growth period witnesses a similar dietary patterns as a mother, increasing the likelihood of defective growth (USAID, 2012). Genetics plays a role as well. Studies suggest genetic factors such as maternal height, and weight play critical role in shaping up a child's growth pattern (Addo *et al.*, 2013; Skåren, Davies and Bjørnerem, 2020). Our results confirm the role of mother's weight and height in offspring linear growth.

Results indicate access to healthcare facilities increasing the likelihood of a child having normal linear growth. Maternal and child access to healthcare facilities provides primary health care services for diagnose, cure, or ameliorate diseases for child as well as mother (National Academies of Sciences, Engineering, and Medicine 2018). These factors decisively influence the health status of children. The results indicate the number of antenatal visits during pregnancy positively impacts the likelihood of a child's normal linear growth. Antenatal visit or regular screening help to monitor and prevent the early complications and diseases of mother which in turn maintain the healthy growth of a child resulting in optimal birth outcomes for both mother and child (Patel *et al.*, 2016; Akhtar *et al.*, 2018).

Further, results show lactating mothers who have not received benefits from Anganwadi/ICDS (Integrated Child Development Services) centre, their children are at higher risk of impaired linear growth. Mother's diet directly influences on breastmilk and thus, it is necessary for mothers to consume nutrients diet while breastfeeding (La Leche League GB, 2021). Consequently, the Anganwadi/ICDS centre by providing supplementary nutrients while breastfeeding of mothers can help for transmission of various nutrients to mother and a baby (Lamberti *et al.*, 2011). However, the evaluation report on ICDS by Government of India, underlying issues including infrastructural problems, the lack of utilization due to poor awareness about the programs and monitoring mechanism as major barriers of achieving benefits of this programme (Programme Evaluation Organisation Planning Commission Government of India, 2011). These barriers lead to preventing vulnerable population, women's and children to not achieving the essential nutrient requirements and increase the risk of stunted growth among children.

5.2 Factors influencing wasted growth of children

Two factors become significant for children from poverty ridden communities to maintain proper weight as per height, namely, child's health status and mother's physical and social status. In other words, the relationship (mesosystem) and social interaction (macrosystems) based variables came as significant from the Bronfenbrenner's ecological systems theory perspective.

Child facing health problems like fever, diarrhoea, and cough may demonstrate wasted growth or thinness (Weisz *et al.*, 2011). Our results confirm the same. Prevalence of fever, diarrhoea, and cough as the common symptoms of infectious diseases (Mayo Clinic, 2021) results in malabsorption of nutrients and loss of appetite which in turn lead to nutrient losses and weight loss in a child's body (Katona and Katona-Apte, 2008). Consequently, increase in the incidence or exacerbation of malnutrition such as wasted growth of a child can be seen (National Research Council (US), 1985).

Vaccination supports better health, and our results confirm the same. The results highlight receiving polio vaccination as associated with lower likelihood of a child's wasted growth. The polio vaccines prevent poliomyelitis, a highly infectious viral disease which can lead to severe respiratory illness and gastroenteritis (Mehndiratta, Mehndiratta and Pande, 2014; Ceveland Clinic, 2021). The polio vaccine enhances the immune system of a child's body against these health problems (WHO, 1993; FAO, 2017a).

The mesosystem relationship between the mother and the health systems came as significant in the results. Access to health care facilities provides necessary primary health care services for diagnose, cure, or ameliorate diseases for child as well as mother (National Academies of Sciences, Engineering and and Medicine, 2018) The absence of these facilities can aggravate the risk of chronic health issues which could deprive a child of essential nutrients required for growth and consequently result in malnutrition. Evidence reveals poor access to essential services including quality healthcare facilities as one of the main causes of impaired child growth (WHO, World Bank Group, 2018).

The macrosystem variables of social interactions, namely, type of residency, mother's working status and mother's marital status associate strongly with the likelihood of a child experiencing wasted growth. We find positive association between urban residency and lower rate of wasted growth. Urban residents have a better access to essential services including number and scope of health services and providers, pharmacists, social workers, and public transportation. Hence, the challenges faced by rural residents contribute to health disparities in these regions (Karen Appold, 2019). Furthermore, we find maternal non-working status (in last 12 months) as positively related to better growth. Non-working mothers can spend more time for healthcare activities including feeding and care of a child which contributes to the enhancement of the likelihood of a child' healthy growth (Hsin and Felfe, 2014). However, the marital status of divorce works the opposite and can lead to the possibility of wasted growth.

5.3 Factors influencing underweight growth of children

The findings from the models highlight the significance of environmental levels of exosystem and mesosystem affecting the likelihood of underweight condition in children. Other than the health status in terms of anaemia at all levels (mild, moderate, and severe), health access variables can negatively influence the child's weight. Moreover, the results show poor dietary adequacy (particularly lack of iron) increasing the risk of a child's defective growth in terms of underweight (Locks *et al.*, 2019; Yanagimoto, Ishizaki and Kaneko, 2020).

At the mesosystems level accessing healthcare facilities increases the likelihood of children maintaining proper weight. Maternal access to the healthcare facilities contribute to the timely growth monitoring of a child and prevent the prevalence of physical and mental health complications associated with malnutrition including underweight (Anoop T. Nair *et al.*, 2008). The results illustrate the number of antenatal visits reduces the likelihood of underweight condition in children. WHO suggests minimum 8 antenatal visits as crucial for the health of both mother and the unborn child, for continuous health monitoring (WHO, 2017).

Furthermore, results show post-natal visits for vaccination of the child (DPT and Polio vaccination) creates lesser likelihood of impaired growth status such as underweight. DPT vaccination develops a child's immunization by providing a protection against the diphtheria (infection of throat), tetanus (nerve disease), and pertussis (respiratory illness) (Elana Pearl Ben-Joseph, 2020). The polio vaccines prevent poliomyelitis which adversely influences throat and intestines (Ceveland Clinic, 2021). The prevalence of health problems due to lack of vaccination gets associated with prevalence of underweight (Samiak and Emeto, 2017).

5.4 Factors influencing overweight growth of children

Lastly, the findings from the models signify the importance of a child's individual characteristics as well as mesosystem environmental level of maternal weight and height influencing the likelihood of overweight condition in children. Results demonstrate low probability of overweight condition among anaemic children. However, dietary diversity (DDS) positively impacts weight and may lead to weight gain. Furthermore, results show mother's weight as significantly associated with weight gain. Mother's weight influences the quality of lactation which plays an integral role in influencing the likelihood of a child's future overweight or obesity (Jevitt, Hernandez and Groër, 2007). Moreover, literature demonstrates the strong genetic association between mother and child anthropometry, which can play a role in likelihood of a child's overweight condition (Tigga and Sen, 2016). Our results confirm the same.

6. Conclusion

Broadly, our findings highlight four critical contributors to the likelihood of child malnutrition in the forms of stunted, wasted, underweight, and overweight. These include (1) a child's individual health status including anaemia, and prevalence of health problems such as fever, diarrhoea, and cough, (2) dietary diversity and micronutrients consumption, (3) access to healthcare services, and (4) social welfare supporting programs (ICDS).

Additionally, employing the Bronfenbrenner's ecological systems theory, the results find three environmental ecosystems, namely, microsystem, mesosystem, and exosystem as most significant. Under the microsystem environmental level, the importance of maternal health in particular anaemia levels and maternal access to healthcare stands out in explaining the likelihood of a child's stunted and underweight growth. Besides, the findings confirm nutritional factors such as DDS and iron supplements intake as critical for linear growth of poverty ridden children. Therefore, at the immediate environmental level, accessibility to diverse nutritional foods and micronutrients supplementary forms a major challenge to tackle malnutrition among poverty ridden children.

Under the mesosystem environmental levels, the findings indicate access to healthcare as significant in shaping a c
ild's health status. Healthcare provides proper care and nutritional counselling which in turn protects a child from the prevalence of malnutrition including stunted, wasted, underweight and overweight. In the case of poverty ridden populations with limited access to healthcare, this becomes significantly more critical.

Under the exosystem environmental level affirms the significance of social welfare program called as ICDS for benefits of lactating mothers while breastfeeding that contributes to supporting nutritional demands of a baby by ensuring absolute quantities of nutrients transferred from mothers to infants through the breast milk. Consequently, this could improve the baby's linear growth and development. Therefore, this is an urgent need with particular focus on poverty ridden communities and vulnerable mothers with massive unmet requirements including lack of access to nutrient and variety of foods, as well as mothers with lower awareness and less access for utilization of this program.

6.1 Implications for research and practice

The findings of this paper clearly imply that to tackle the triple burden of child malnutrition it is crucial to provide the mothers a better access to the health care facilities. Improving accessibility to healthcare services particularly for mothers in poverty ridden communities would lead to timely healthcare, including growth monitoring of height and weight, nutritional health counselling regarding vaccination and multivitamin access, and dietary diversity, and prevent the health complications such as anaemia in a child. Furthermore, other than the opportunity of use through easy physical access, removal of other barriers to access, namely, financial, social, and/or cultural become critical we well. These barriers can limit the utilization of services, even in places where they are "available."

Furthermore, maternal access to healthcare services can help mothers to maintain and improve their health status and prevent the health issues which has direct impact on likelihood of children malnutrition during growth period. However, policy makers need to ask how aware are the mothers about the importance of accessing healthcare for the benefit of their health and their child? Studies on awareness are many and diverse, but lacunae in awareness appear to cut across the women in India. Often low educational status, poor functional literacy, and low priority for health leads to the lack of awareness. Effort to create awareness, thus, becomes important as well.

Lastly, support and enhancing awareness of health and nutrition programs such as ICDS particularly in poverty ridden communities with limited access to nutrition (e.g., healthy, and diverse nutritious diets) and health (e.g., primary child illness preventable awareness) knowledge could help to promote the continuum of care and addressing high burden

of maternal and child malnutrition in India. Moreover, striving to implement programmes innovatively in order to make a dent on improving maternal and child health and nutrition contributes to reduce the likelihood of impair growth and poor health status among children in poverty ridden communities.

Acknowledgments
The authors would like to acknowledge the United States Agency for International Development (USAID) and Ministry of Health and Family Welfare, Government of India for providing access to the Demographic and Health Survey (DHS) (also known as NFHS-4), conducted in India. This research is funded by a grant from the Akshaya Patra Foundation, India (grant number SP/APRL-19-0001).

References

Abu-Ouf, N. M. and Jan, M. M. , 'The impact of maternal iron deficiency and iron deficiency anemia on child's health', *Saudi Medical Journal*, 36(2), pp. 146–149. 2015.

Adarsh, S. S. A. C. N. L. M., *NFHS-5: Child mortality drops, prevalence of malnutrition remains high*, *NFHS-5 DownToEarth*. Available at: https://www.downtoearth.org.in/news/health/nfhs-5-child-mortality-drops-prevalence-of-malnutrition-remains-high-74694 (Accessed: 2 May 2021). 2020

Addo, O. Y. *,* 'Maternal height and child growth patterns', *Journal of Pediatrics*. Elsevier Ltd, 163(2), pp. 549-554.e1. doi: 10.1016/j.jpeds.2013.02.002. 2013

Afsharinia, B. *,* 'Impact of Maternal Conditions on The Nutritional Health of Children in India', *Biomedical Journal of Scientific & Technical Research*, 36(1), pp. 28115–28121. doi: 10.26717/bjstr.2021.36.005780. 2021

Agadjanian, V. and Jansen, N. A. , 'Historical Legacies , Social Capital , and Women ' s Decision-Making Power : Religion and Child Nutrition in Mozambique', *Journal of Religion and Health*. Springer US, 57(4), pp. 1458–1472., 2018

Akhtar, S. *,* 'Knowledge Attitude and Practice Regarding Antenatal Care among Pregnant Women in Rural Area of Lahore', *International Journal of Social Sciences and Management*, 5(3), pp. 155–162. doi: 10.3126/ijssm.v5i3.20604. 2018

de Almeida, G. M., Recine, E. and Fagundes, A., Objectives and Competencies in Food and Nutrition Education in the Brazilian Undergraduate Nutrition Program', *Journal of Nutrition Education and Behavior*, 000(000). doi: 10.1016/j.jneb.2019.10.001. 2019.

Ananya Mandal, M., *Causes of malnutrition*, *News Medical Life Science*. Available at: https://www.news-medical.net/health/Causes-of-malnutrition.aspx (Accessed: 3 May 2021. 2019

Anoop T. Nair *et al,* 'Social media, vaccine hesitancy and trust defcit in immunization programs: a qualitative enquiry in Malappuram District of Kerala, India', *Maternal & Child Nutrition,* pp. 86–117. doi: 10.1111/j.1740-8709.2007.00125. 2008)

BANK, W. , 'Injury Prevention and Environmental Health', *National Center for Biotechnology Information*. doi: https://doi.org/10.1596/978-1-4648-0522-6_ch1. 2017.

Barros, F. C. *et al.* , 'Socioeconomic inequities in the health and nutrition of children in low / middle income countries Iniqüidades sociais na saúde e nutrição de crianças em países de renda baixa e média', *Public Health Journal*, 44(1), pp. 1–16. doi: 10.1590/s0034-89102010000100001. 2010

Bronfenbrenner, U., *The Ecology of Human Development*. HARVARD UNIVERSITY PRESS Cambridge, Massachusetts, and London, England. Available at: https://khoerulanwarbk.files.wordpress.com/2015/08/urie_bronfenbrenner_the_ecology_of_human_developbokos-z1.pdf (Accessed: 16 June 2021). 1979

Bryce, J. *et al,* 'WHO estimates of the causes of death in children', *National Center for Biotechnology Information (NCBI)*, pp. 1147–1152. doi: 10.1016/S0140-6736(05)71877-8. 2005

Ceveland Clinic , *Polio (Poliomyelitis): What Is It, Symptoms, Causes & Vaccine*, *CevelandClinic*. Available at: https://my.clevelandclinic.org/health/diseases/15655-polio (Accessed: 22 June 2021). 2021

Chaudhary, P. and Agrawal, M., Asian Journal of Clinical Nutrition Research Article Malnutrition and Associated Factors among Children below Five Years of Age Residing in Slum Area of Jaipur City , Rajasthan , India Pragati Chaudhary and Mukta Agrawal'. doi: 10.3923/ajcn.2019.1.8. 2019

ChildrenforHealth , *Malnutrition Information Sheet | Children for Health*, *ChildrenforHealth*. Available at: https://www.childrenforhealth.org/malnutrition/ (Accessed: 3 May 2021). 2021

Chinyoka, K. , 'Impact of Poor Nutrition on the Academic Performance of Grade Seven learners : A Case of Zimbabwe', (January). doi: 10.5296/ijld.v4i3.6169. 2016

Chopra, M. , Risk factors for undernutrition of young children in a rural area of South Africa', 6(7), pp. 645–652. doi:

10.1079/PHN2003477. 2003

Christensen, C. , World hunger: a structural approach', *International Organization*. Cambridge University Press, 32(3), pp. 745–774. doi: 10.1017/S0020818300031921. 2009

Cleveland Clinic , *Anemia: Symptoms, Types, Causes, Risks, Treatment & Management*, *Cleveland Clinic*. Available at: https://my.clevelandclinic.org/health/diseases/3929-anemia (Accessed: 12 July 2021). 2021

Diamanti, A. , 'Prevalence and outcome of malnutrition in pediatric patients with chronic diseases: Focus on the settings of care', *Clinical Nutrition*. Elsevier Ltd, 38(4), pp. 1877–1882, 2019

Dinku, A. M., Mekonnen, T. C. and Adilu, G. S, Child dietary diversity and food (in)security as a potential correlate of child anthropometric indices in the context of urban food system in the cases of north-central Ethiopia', *Journal of Health, Population and Nutrition*. Journal of Health, Population and Nutrition, 39(1), pp. 1–11. 2020

EconomicTimes , *Malnutrition behind 69 per cent deaths among children below 5 years in India: UNICEF report - The Economic Times*, *EconomicTimes*. 2019.

El-Khuffash and Afif, P. J. M.,'Oxygen Transport and Delivery', in *Fetal and Neonatal Physiology (Fifth Edition)*, pp. 724-737.e2.2017.

El-Sheikh, M. , Marital Psychological and Physical Aggression and Children's Mental and Physical Health: Direct, Mediated, and Moderated Effects', *J Consult Clin Psychol*, 78(1), pp. 1–7. 2008.

Elana Pearl Ben-Joseph , *Your Child's Immunizations: Diphtheria, Tetanus & Pertussis Vaccine (DTaP) (for Parents) - Nemours KidsHealth*, *KidsHealth*. Available at: https://kidshealth.org/en/parents/dtap-vaccine.html (Accessed: 22 June 2021).

FAO ,'CLIMATE CHANGE AND FOOD SECURITY ': Available at: http://www.fao.org/3/a-au035e.pdf.2018.

FAO , *Frequently Asked Questions on Immunization*, *JSI India for the Ministry of Health & Family Welfare*.

FAO,*The Impact of disasters and crises on agriculture and Food Security*. Available at: 2017a.http://www.fao.org/emergencies/resources/documents/resources-detail/en/c/1106859/.

FAO , *A review of studies examining the link between food insecurity and malnutrition*, *Technical Paper*. 2018.

Franchetti, Y. and Ide, H. , 'Socio-demographic and lifestyle factors for child ' s physical growth and adiposity rebound of Japanese children : a longitudinal study of the 21st century longitudinal survey in newborns', pp. 1–12.2014.

Galgamuwa, L. S. , 'Nutritional status and correlated socio-economic factors among preschool and school children in plantation communities , Sri Lanka', *BMC Public Health*. BMC Public Health, pp. 1–11.2017.

Haque, M. , 'Strengthening primary health-care services to help prevent and control long-term (Chronic) non-communicable diseases in low- and middle-income countries', *Risk Management and Healthcare Policy*, 13, pp. 409–426., 2020.

Harvard T.H. Chan, *Iron | The Nutrition Source | Harvard T.H. Chan School of Public Health*, *Harvard T.H. Chan School of Public Health*. Available at: https://www.hsph.harvard.edu/nutritionsource/iron/ Accessed: 23 July 2021.

HINDRISE , *Undernutrition in India - The Matter of Worry in Modern Scenario*, *HINDRISE* . Available at: https://hindrise.org/resources/undernutrition-in-india-the-matter-of-worry-in-modern-scenario/ (Accessed: 8 December 2021.

Hsin, A. and Felfe, C., 'When Does Time Matter? Maternal Employment, Children's Time With Parents, and Child Development', *Demography*, 51(5), pp. 1867–1894.2014.

Hussein, K. H. , 'Environmental factors of malnutrition diseases among children less than five years old in Babylon province', *Mesopotamia Environmental Journal*, 2(3), pp. 1–10. 2016.

Ijarotimi, O. S., Determinants of Childhood Malnutrition and Consequences in Developing Countries', *Current Nutrition Reports*, pp. 129–133., 2013.

IPC-IG and FAO , *Leveraging food systems for poverty and*, *e Food and Agriculture Organization of the United Nations (FAO) and the International Policy Centre for Inclusive Growth (IPC-IG2020.*

Jain, P., 'A Study of Environmental Factors Affecting Nutritional Status of under 5 Children in Rural Area of North India', (September). doi: 10.5958/0976-5506.2018.00975.0. 2018

Jevitt, C., Hernandez, I. and Groër, M. , Lactation Complicated by Overweight and Obesity: Supporting the Mother and Newborn', *Journal of Midwifery and Women's Health*, 52(6), pp. 606–613. doi: 10.1016/j.jmwh.2007.04.006. 2007

Jha, A. B. and Warkentin, T. D. , 'Biofortification of pulse crops: Status and future perspectives', *Plants*, 9(1). doi: 10.3390/plants9010073. 2020

Källander, K. , 'Delayed care seeking for fatal pneumonia in children aged under five years in Uganda: A case-series study', *Bulletin of the World Health Organization*, 86(5), pp. 332–338. doi: 10.2471/BLT.07.049353. 2008

Karen Appold, *Top Healthcare Changes Associated with Urban Growth*, *Managed Healthcare*.

Katona, P. and Katona-Apte, J. (2008) 'The interaction between nutrition and infection', *Clinical Infectious Diseases*, 46(10), pp. 1582–1588. doi: 10.1086/587658. 2019

Khiem Nguyen, *2020 State of Food Security and Nutrition in the World report: Rising hunger and COVID-19 present formidable challenges | IFPRI : International Food Policy Research Institute*, *IFPRI*. Available at: https://www.ifpri.org/blog/2020-state-food-security-and-nutrition-world-report-rising-hunger-and-covid-19-present (Accessed: 11 December 2021). 2020

Krieger, J. and Higgins, D. L, 'Housing and Health : Time Again for Public Health Action', *American Journal of Public Health*, 92(5), pp. 758–768. doi: 10.2105/AJPH.92.5.758. 2002

Lamberti, L. M., 'Breastfeeding and the risk for diarrhea morbidity and mortality', *BMC Public Health*, 9(2), pp. 171–174. 2011

La Leche League GB, *Breastfeeding and a Mother's Diet: Myths and Facts*, *La Leche League GB*. Available at: https://www.laleche.org.uk/breastfeeding-and-a-mothers-diet-myths-and-facts/ (Accessed: 20 August 2021). 2021

Lee, Y. Y. , 'The Intertwined Relationship Between Malnutrition and Poverty', *Frontiers in Public Health | www.frontiersin.org*, 1, p. 453. doi: 10.3389/fpubh.2020.00453. 2020

Locks, L. M., 'Changes in growth, anaemia, and iron deficiency among children aged 6–23 months in two districts in Nepal that were part of the post-pilot scale-up of an integrated infant and young child feeding and micronutrient powder intervention', *Maternal and Child Nutrition*, 15(2), pp. 1–13. doi: 10.1111/mcn.12693. 2019

Makadia, K, Maternal factors affecting malnutrition status of children of 1 to 5 years age 1 Study to Assess the Maternal Factors Influencing Undernutrition among 3 to 6 Year Old Children of Davangere City', *National Journal of Community Medicine*, (July), pp. 2–6. Available at: https://www.researchgate.net/publication/318502446%0AMaternal. 2017

Maleta, K., Undernutrition', *Malawi Medical Journal*, 18(December), pp. 189–205. Available at: https://docksci.com/undernutrition_5a07ff4ad64ab20cdb17e4fd.html. 2006.

Martins, V. J. B. , 'Long-Lasting Effects of Undernutrition', *International Journal of Environmental Research and Public Health*, pp. 1817–1846. doi: 10.3390/ijerph8061817. 2011

Maurya, N. K. and Kushwaha, R., 'National Nutrition Programmes in India', in *Research Trends in Home Science and extension*. First. Akinik Puplication, pp. 20–35. Available at: https://www.researchgate.net/publication/333866257_National_Nutrition_Programmes_in_India. 2018

Mayo Clinic, *Infectious diseases - Symptoms and causes - Mayo Clinic*, *Mayo Clinic*. Available at: https://www.mayoclinic.org/diseases-conditions/infectious-diseases/symptoms-causes/syc-20351173 (Accessed: 22 July 2021).

Mehndiratta, M. M., Mehndiratta, P. and Pande, R. , 'Poliomyelitis: Historical Facts, Epidemiology, and Current Challenges in Eradication', *The Neurohospitalist*, 4(4), pp. 223–229. 2014.

Moradhvaj and Saikia, N., Gender disparities in health care expenditures and financing strategies (HCFS) for inpatient care in India', *SSM - Population Health*. Elsevier Ltd, 9(December 2018), p. 100372. doi: 10.1016/j.ssmph.2019.

Mwaniki EW, M. A., Nutrition status and associated factors among children in public primary schools in Dagoretti , Nairobi , Kenya', *African Health Sciences*. doi: 10.4314/ahs.v13i1.6. 2013

National Academies of Sciences, Engineering and and Medicine , *Opportunities for Improving Programs and Services for Children with Disabilities*, *Opportunities for Improving Programs and Services for Children with Disabilities*. Edited by and E. B. Amy J. Houtrow, Frank R. Valliere. Washington, DC: The National Academies Press..2018.

National Research Council (US) , NUTRITIONAL CONSEQUENCES OF ACUTE DIARRHEA', in *utritional Management of Acute Diarrhea in Infants and Children.* US: National Academies Press (US). Available at: https://www.ncbi.nlm.nih.gov/books/NBK219100/ (Accessed: 21 May 2021). 1985

Olaf Müller, M. K., 'Malnutrition and health in developing countries', *International Journal of Precision Engineering and Manufacturing*, 17(5), pp. 671–677. doi: 10.1007/s12541-016-0082-0. 2016

Olivia Guy-Evans, *Bronfenbrenner's Ecological Systems Theory | Simply Psychology*, *Simply Psychology* . Available at: https://www.simplypsychology.org/Bronfenbrenner.html (Accessed: 16 June 2021). 2020

Panda, B. K. , 'Malnutrition and poverty in India: Does the use of public distribution system matter?', *BMC Nutrition*. BMC Nutrition, 6(1), pp. 1–14. doi: 10.1186/s40795-020-00369-0. 2020

Patel, B. B. , A study on knowledge and practices of antenatal care among pregnant women attending antenatal clinic at a Tertiary Care Hospital of Pune, Maharashtra', *Medical Journal of Dr. D.Y. Patil University*, 9(3), pp. 354–362. doi: 10.4103/0975-2870.182507. 2016

Popkin, B., Adair, L. and Ng, S. , 'NOW AND THEN: The Global Nutrition Transition: The Pandemic of Obesity in Developing Countries', *Nutrition Reviews*, 70(1), pp. 3–21. doi: 10.17615/pje5-4k90. 2012

Programme Evaluation Organisation Planning Commission Government of India (2011) *Evaluation Report on Integrated Child Development Services Volume I*. Available at: http://planningcommission.nic.in/reports/peoreport/peoevalu/peo_icds_v1.pdf.

Rathnayake, K. M., Madushani, P. and Silva, K., 'Use of dietary diversity score as a proxy indicator of nutrient adequacy of rural elderly people in Sri Lanka', *BMC Research Notes*, 5, pp. 2–7. doi: 10.1186/1756-0500-5-469. 2012.

Reinhardt, K. and Fanzo, J., Addressing Chronic Malnutrition through Multi-Sectoral, Sustainable Approaches: A Review of the Causes and Consequences', *Frontiers in Nutrition*, 1(August), pp. 1–11. doi: 10.3389/fnut.2014.00013. 2014

Reyes, H., 'The family as a determinant of stunting in children living in conditions of extreme poverty : a case-control study', 10, pp. 1–10. doi: 10.1186/1471-2458-4-57. 2004

Rice, A. L., 'Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries', *BulletinoftheWorldHealthOrganization*, 78(10), pp. 1207–1221. doi: 10.1590/S0042-96862000001000007. 2000

Saaka, M. and Osman, S. M. , 'Does Household Food Insecurity Affect the Nutritional Status of Preschool Children Aged 6–36 Months?', *International Journal of Population Research*, 2013(June 2013), pp. 1–12. ,. 2013

Sachdev, Y. and Dasgupta, J., Integrated child development services (ICDS) scheme', *Medical Journal Armed Forces India*, 57(2), pp. 139–143. 2001.

Samiak, L. and Emeto, T. I. , 'Vaccination and nutritional status of children in Karawari, East Sepik Province, Papua New Guinea', *PLoS ONE*, 12(11), pp. 1–12. 2017

Scharte, M. and Bolte, G., 'Increased health risks of children with single mothers: The impact of socio-economic and environmental factors', *European Journal of Public Health*, 23(3), pp. 469–475. , 2013.

Schell, L. M., Gallo, M. V. and Ravenscroft, J., 'Environmental influences on human growth and development: Historical review and case study of contemporary influences', *Annals of Human Biology*, 36(5), pp. 459–477. , 2009.

Schroeder, D. G. and Brown, K. H., 'Nutritional status as a predictor of child survival : summarizing the association and quantifying its global impact', *Bulletin of the World Health Organization*. Available at: , 1994.

Sen, J., Roy, A. and Mondal, N., 'Association of maternal nutritional status, body composition and socio-economic variables with low birth weight in India', *Journal of Tropical Pediatrics*, 56(4), pp. 254–259. doi: 10.1093/tropej/fmp102. 2009

Shin, H. and Kim, J. , Differences in income-related inequality and horizontal inequity in ambulatory care use between rural and non-rural areas: Using the 1998-2001 U.S. National Health Interview Survey data', *International Journal for Equity in Health*, 9, pp. 1–11. doi: 10.1186/1475-9276-9-17. 2010

Singh, A, Childhood Malnutrition in India', *Perspective of Recent Advances in Acute Diarrhea Book*. doi: 10.5772/intechopen.89701. 2020a

Singh, A., We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists , for scientists TOP 1 % Childhood Malnutrition in India', in *Perspective of Recent Advances in Acute Diarrhea*. IntechOpen, 7th floor 10 Lower Thames Street London, EC3R 6AF, UK Phone: +44 (0)203 972 6202. doi: http://dx.doi.org/10.5772/intechopen.89701 either. 2020b

Skåren, L., Davies, B. and Bjørnerem, Å., The effect of maternal and paternal height and weight on antenatal, perinatal and postnatal morphology in sex-stratified analyses', *Acta Obstetricia et Gynecologica Scandinavica*, 99(1), pp. 127–136., 2020.

Smith, L. C., Ruel, M. T. and Ndiaye, A., 'Why is child malnutrition lower in urban than in rural areas? Evidence from 36 developing countries', *World Development*, 33(8), pp. 1285–1305. doi: 10.1016/j.worlddev.2005.03.002. 2005

Soliman, A., De Sanctis, V. and Kalra, S. , 'Anemia and growth', *Indian Journal of Endocrinology and Metabolism*. Medknow Publications, 18(Suppl 1), pp. S1–S5. doi: 10.4103/2230-8210.145038. 2014

Stewart, C. P., 'Contextualising complementary feeding in a broader framework for stunting prevention', *Maternal and Child Nutrition*, 9(S2), pp. 27–45. doi: 10.1111/mcn.12088. 2013

Steyn, N., 'Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy?', *Public Health Nutrition*, 9(5), pp. 644–650. doi: 10.1079/phn2005912. 2006

Thompson, D. S., 'Socioeconomic factors associated with severe acute malnutrition in Jamaica', *Journal of Economic Theory and Practice*, pp. 1–15. 2017

Tigga, P. L. and Sen, J., 'Maternal body mass index is strongly associated with children ?', *Journal of Anthropology*, p. 10. 2016

Tirivangasi, H. , 'Regional disaster risk management strategies for food security : Probing Southern African

Development Community channels for influencing national policy', *Journal of Disaster Risk Studies*, pp. 1–7. 2017

UNICEF , *The faces of malnutrition | Nutrition | UNICEF*, *UNICEF*. Available at: https://sites.unicef.org/nutrition/index_faces-of-malnutrition.html (Accessed: 13 April 2021).

UNICEF , *2018 Global Nutrition Report reveals malnutrition is unacceptably high and affects every country in the world, but there is also an unprecedented opportunity to end it.*, *UNICEF*. Available at: https://www.unicef.org/press-releases/2018-global-nutrition-report-reveals-malnutrition-unacceptably-high-and-affects (Accessed: 13 April 2021).

UNICEF , *Children , food and nutrition*. Available at: https://www.unicef.org/media/60806/file/SOWC-2019.pdf.

UNICEF 'UNICEF ' s Global Social Protection Programme Framework'. 2019b.

UNICEF *Malnutrition in Children - UNICEF DATA*, *UNICEF*. Available at: https://data.unicef.org/topic/nutrition/malnutrition/ (Accessed: 13 April 2021).

UNICEF , *Malnutrition in Children - UNICEF DATA*, *UNICEF*. Available at: https://data.unicef.org/topic/nutrition/malnutrition/ (Accessed: 7 May 2021). 2021

USAID, *Maternal dietary diversity and the implications for children ' s diets in the context of food security*, *Infant & young child nutrition project*. Available at: http://iycn.wpengine.netdna-cdn.com/files/IYCN_Brief_Maternal_Dietary_Diversity0112.pdf. 2012

Van Cooten, M. H.,'The association between acute malnutrition and water, sanitation, and hygiene among children aged 6–59 months in rural Ethiopia', *Maternal and Child Nutrition*, 15(1), pp. 1–8. doi: 10.1111/mcn.12631. 2019

Vorster, H. H. and Kruger, A. , 'Poverty , malnutrition , underdevelopment and cardiovascular disease : a South African perspective', *CARDIOVASCULAR JOURNAL OF AFRICA*, 18(5), pp. 321–324. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3975540/?report=reader#.2007

Weisz, A. , *The duration of diarrhea and fever is associated with growth faltering in rural Malawian children aged 6-18 months*, *Nutrition Journal*. doi: 10.1186/1475-2891-10-25. 2011

WHO, World Bank Group, O., *Delivering quality health services*, *World Health Organization, World Bank Group, OECD*. Available at: http://apps.who.int/bookorders. 2018

WHO , *The Immunological Basis for Immunization - Module 6: Poliomyelitis*, *Global Programme for Vaccines and Immunization: Expanded Programme on Immunization (WHO)*. 1993.

WHO , *Malnutrition Quantifying the health impact at national and local levels*. Available at: https://www.who.int/quantifying_ehimpacts/publications/MalnutritionEBD12.pdf. 2005

WHO, *WHO Child Growth Standards*. doi: 10.1111/j.1469-8749.2009.03503.x. 2009

WHO , *WHO recommendations on antenatal care for a positive pregnancy experience*, *WHO*. Available at: https://www.who.int/publications/i/item/9789241549912 (Accessed: 15 May 2021).

WHO , *Malnutrition is a world health crisis*, *WHO*. Available at: https://www.who.int/news/item/26-09-2019-malnutrition-is-a-world-health-crisis (Accessed: 21 June 2021).

WHO , *More than one in three low- and middle-income countries face both extremes of malnutrition*, *WHO*. Available at: https://www.who.int/news/item/16-12-2019-more-than-one-in-three-low--and-middle-income-countries-face-both-extremes-of-malnutrition (Accessed: 20 May 2021). 2019b

WHO, *Fact sheets - Malnutrition*, *WHO*. Available at: https://www.who.int/news-room/fact-sheets/detail/malnutrition (Accessed: 25 March 2021). 2020

WHO , *Micronutrients*, *WHO*. Available at: https://www.who.int/health-topics/micronutrients#tab=tab_1 (Accessed: 7 September 2021). 2021a

WHO , *Obesity and overweight*, *WHO*. Available at: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (Accessed: 8 December 2021). 2021b

WHO , *WHO EMRO | Reduce fat, salt and sugar intake | Nutrition site*, *WHO*. Available at: http://www.emro.who.int/nutrition/reduce-fat-salt-and-sugar-intake/index.html (Accessed: 8 December 2021). 2021c

WHO, U., Improving nutrition outcomes with better water, sanitation and hygiene: practical solutions for policies and programmes. Available at: https://www.who.int/water_sanitation_health/publications/washandnutrition/en/.2015

WHO and UNICEF, *Health Implications of Sex Discrimination in Childhood*, *WHO and UNICEF*. doi: 10.2307/1966430. 1987

Yanagimoto, Y., Ishizaki, Y. and Kaneko, K.,'Iron deficiency anemia, stunted growth, and developmental delay due to avoidant/restrictive food intake disorder by restricted eating in autism spectrum disorder', *BioPsychoSocial Medicine*. BioPsychoSocial Medicine, 14(1), pp. 10–12. doi: 10.1186/s13030-020-00182-y. 2020

Zhoua, N. and Cheah, C. S. L, Ecological Risk Model of Childhood Obesity in Chinese Immigrant Children', *HHS Public Access*, 176(3), pp. 139–148. doi: 10.1016/j.appet.2015.02.028. 2016

Acknowledgements

The authors would like to acknowledge the United States Agency for International Development (USAID) and Ministry of Health and Family Welfare, Government of India for providing access to the Demographic and Health Survey (DHS) (also known as NFHS-4), conducted in India. This research is funded by a grant from the Akshaya Patra Foundation, India (grant number SP/APRL-19-0001).

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