ISSN 2455-5886 I Azim Premji University, Working Paper

Working Paper No. 11

Research Area: Development

A Call for Development of a Growth Standard to Measure Malnutrition of School-Age Children

Nilanjan Bhor

May 2018

Azim Premji University

Nilanjan Bhor (2018). *A Call for Development of a Growth Standard to Measure Malnutrition of School-Age Children*
Azim Premji University (Working Paper No. 11).

DOI Link: https://doi.org/10.61933/wps.11.2018.5

Available from:
Azim Premji University
Survey No.66 Burugunte Village,
Bikkanahalli Main Road,
Sarjapura, Bengaluru – 562125, India

About the Working Paper Series

The working paper series aims at reflecting the range of work done across the Azim Premji Foundation, including the Field Institutes and the University, and disseminating this work to a broader audience. University faculty, members of Field Institutes of the Foundation as well as students graduating from the University may contribute to the series.

The findings, interpretations and conclusions expressed in these papers are entirely those of the authors and do not necessarily represent the views of Azim Premji University.

For all enquiries and feedback, please contact: **wps@apu.edu.in**

Abbreviations

BMI	Body Mass Index
CDC	Center for Disease Control
DLHS	District Level Household and Facility Survey
HUMAG	Human Measurements Anthropometry and Growth
IAP	Indian Academy of Pediatrics
ICMR	Indian Council of Medical Research
IOTF	International Obesity Task Force
LMS	Lambda-Mu-Sigma
NCHS	National Center for Health Statistics
NFHS	National Family Health Survey
NHES	National Health Examination Survey
NHANES	National Health and Nutrition Examination Survey
NSHG	National Study of Health and Growth
RSoC	Rapid Survey of Children
SD	Standard Deviation
U.S.	United States
U.K.	United Kingdom
WHO	World Health Organisation

A Call for Development of a Growth Standard to Measure Malnutrition of School-Age Children

Nilanjan Bhor

Abstract: *There is no globally established standard for measuring malnutrition among children aged 5-18 years. Growth references are used as a standard but there are many limitations to using such references to assess nutritional status of Indian children. As per the World Health Organization, standards and references both serve as a basis for comparison, but each enables a different interpretation. A standard defines how children should grow; and deviations from the pattern it prescribes are evidence of abnormal growth. A reference, on the other hand, does not provide a basis for such value judgments, although in practice, references often are mistakenly used as standards.*

This paper has conducted a methodological review of prevalence of malnutrition from openly accessible literature pertaining to assessment of nutritional status of school-going children in India from the year 2000 to 2016. The methodological review reveals that a combination of different national and international references have been used in assessing nutritional status of Indian children. International references includes NCHS 1977, CDC 2000, WHO 2007, IOTF 2012 extended Body Mass Index (BMI) cut-offs, Gomez classification, Waterlow's classification and national references such as - Agarwal standards, ICMR reference values, IAP reference and BMI cut-off for overweight & obesity of Indian children. A new national growth reference has been recently developed by Marwaha and others (2011) for BMI, but no assessment of nutritional status using this reference was found. Each of these methods was then applied to a database containing height, weight, age and sex of 5340 school-going children.

Though there are three nutritional indicators for school-age children, majority of the study conducted used only BMI chart to assess nutritional status. Therefore BMI-for-age is considered for the analysis to i) understand the methodological application of the above growth references ii) compare the differences in nutritional status and iii) recommend an appropriate growth reference (from those available) to assess the nutritional status of Indian school-age children. The literature review also reveals that malnutrition among school-age children is prevalent in India. There is no national level data available to support this judgement across regions, gender and caste. Given a likely high prevalence of malnutrition, this paper calls for the development of a growth standard to measure malnutrition among school-age children in India. Though this paper is focused on malnutrition, it simultaneously provides similar importance to over growth. A growth Standard therefore fills up such gaps in measuring double burden of malnutrition i.e. under-nutrition and over-nutrition.

Keywords: *Anthropometry, Growth charts, Malnutrition, School-age children*

A Call for Development of a Growth Standard to Measure Malnutrition of School-Age Children

Nilanjan Bhor

1. Measuring Child Malnutrition

The National Policy for Children 2013 recognized a child *'as any person below the age of 18 years'* (GoI, 2013). In India, children are categorized into two groups in the context of measuring malnutrition: children under 5 and children aged 5-18 years. National level surveys measure malnutrition among children under 5 years of age. Despite acknowledging that there is likely a high prevalence of malnutrition among school-age children and a proliferation of research studies and literature on 'nutritional status of school-going children', national level surveys like the National Family Health Survey (NFHS), District Level Household and Facility Survey (DLHS) and the Rapid Survey on Children (RSoC) have failed to capture data on nutritional status of children aged 5-18 years.

While there are methodological challenges in constructing growth charts which also need to be periodically revised and updated with nationally and internationally representative data, the existing country specific and international growth charts are valuable tools to assess the nutritional status of children. These existing charts help to make important policy choices based on the prevalence of malnutrition in the surveyed population. Age and sex specific anthropometric information (such as age, sex, height and weight) are essential to measure child nutritional status; and appropriate growth charts for this purpose are available for children ranging from 0-18 years of age. While examining the information available regarding anthropometric measures of children's growth, it is important to be clear about some important concepts: (i) the difference between 'growth standard' and 'growth reference'; (ii) commonly measured nutritional indicators; and (iii) cut-off points in terms of percentile and Z score (or Standard Deviation).

1.1 Growth Standard vs. Growth Reference

There are two types of growth charts: growth standards and growth references. As per the World Health Organization (2006a), standards and references both serve as a basis for comparison, though each enables a different interpretation. A standard defines how children should grow and any deviation is taken as an evidence of abnormal growth. Growth references on the other hand are *descriptive* and are prepared from a given population, which is thought to be growing in the best possible state of nutrition and health in a given community. A reference, consequently, does not provide as sound a basis for value judgments, although in practice, references often are mistakenly used as standards.

Growth standards thus are *prescriptive* and define how a population of children should grow given the optimal nutrition and optimal health. Here all the environmental variables are controlled. Growth references being descriptive represent how children are actually growing rather than how they should be growing (Khadilkar, 2011). The WHO growth charts for children under five years, therefore, is an example of growth standard (WHO, 2006). They define how children of the world under the age of 5 years would grow if most of the controllable variables are functioning optimally. As opposed to this, Agarwal's data and Indian Growth Charts by Khadilkar for affluent children are examples of growth references, which describe how children in India were growing at the given time (Agarwal, 1992; Khadilkar, 2009).

The advantage of having a growth standard such as WHO 2006 is that children of all countries, races, and ethnicity can be compared against a single standard, and thus assessment becomes easier and more objective. The disadvantage of using these charts is that they are likely to over-diagnose underweight and stunting in a large number of apparently normal children (Khadilkar, 2010) in developing countries such as India.

The advantage of a growth reference is that it is a true representative of the existing growth pattern of children and allows the study of secular trends in terms of height, weight and obesity. The disadvantage of reference curves is that they need to be updated at least once a decade and with the recent rising incidence of obesity, they are likely to define overweight children as normal (Khadilkar, 2011). The main value of the reference is to make possible comparisons between different populations or descriptions of the situation at different times. It should be clear, of course, that the reference is not necessarily an optimum, although derived from apparently healthy children (Waterlow, 1997).

1.2 Nutritional indicators for school-age children

The four building blocks of anthropometric indices are age, sex, height and weight. Each variable provides one piece of information about children; and when a combination of variables (usually two) are used together, they are termed an 'index' (Cogill, 2003). The three sex and age specific indicators that are used to measure nutritional imbalance in children are underweight (weight-for-age), stunting (height-for-age) and BMI-for-age.

Table 1. Commonly used nutritional indicators

Index	Outcomes	Indication of growth /nutrition problems
Weight-for-age	Underweight (inadequate weight related to age)	Both chronic and acute malnutrition
Height-for-age	Stunted (inadequate height related to age)	Chronic malnutrition
BMI-for-age	Low BMI-age or High BMI-age	Low BMI-age (or under-nutrition) Overweight and Obesity

BMI-for-age is widely used to measure malnutrition, overweight and obesity among school-age children in India and internationally. Almost all country specific and international growth references provide sex and age specific cut-offs for BMI. The advantage of using BMI is that it provides a good indicator for levels of body fat. It is known that having a BMI that is either too low or too high is associated with an increased risk of ill health during childhood as well as later in life (Dinsdale, 2011). Given the ease of measuring height and weight in the field setting, BMI is an appropriate and acceptable indicator for assessing the risk of under/overweight in children and adolescents (Malina, 1999).

1.3 Percentile or Z-score in anthropometry

Smoothed percentile curves and Z-scores are widely used in measuring nutritional status and growth such as under-nutrition (underweight, stunting and wasting) and over-nutrition (overweight and obesity). According to Wang and Kuczmarski a percentile is the value of a variable below which a certain percentage of observations (or population) falls, i.e., the percentile refers to the position of an individual on a given reference distribution (Wang et al., 2012; Kuczmarski et al., 2002). The widely used percentiles include the 3rd, 5th, 50th (median), 85th, 95th, 97th and 99th. Individuals below the 3rd and above the 97th percentile are considered to be out of normal range. The 85th and 95th percentile mostly used in BMI charts indicate overweight and obesity cut-offs. Percentiles are used as clinical indicators in the United States for measuring malnutrition or obesity.

Table 2. Comparison of percentiles and Z-scores

	Percentiles	Z-scores
1. Definition	The percentage of observations (or population) falls below the value of a variable	The standard deviation from the mean, when the distribution is normal
2. Scale	Rank scale	Continuous scale
3. Strengths	(a) Intuitively more understandable (b) Indicating the expected prevalence	(a) Allowing comparisons across ages and sexes (b) Able to quantify the extreme values (c) Good for assessing the longitudinal changes in growth status

	Percentiles	Z-scores
4. Limitations	(a) Not comparable across different anthropometries (b) Extreme values are lumped to the highest/lowest percentile (c) Not suitable for assessing longitudinal growth status	Difficult to perceive unlike percentiles, especially for the public
5. Under normal distribution, a percentile must correspond to a fixed Z-score	Following is the list of usually used percentile – Z-score conversion values	
	0.2 (or 0.1 or 1st)	-3
	2.3 (or 3rd)	-2
	2.5	-1.96
	5th	-1.64
	15th	-1.04
	16th (or 15th or 15.9)	-1
	50th (median)	0
	84th (or 85th or 84.1)	+1
	85th	+1.04
	95th	+1.64
	97.5	+1.96
	97.7 (or 97th)	+2
	99.8 (or 99.9 or 99th)	+3

Source: Wang et al., 2012

Recently however, many international agencies including the World Health Organisation (WHO) recommend the use of Z-scores. The advantage of using Z-scores is that 'firstly, Z -scores are calculated based on the distribution of the reference population (both the mean and the standard deviation); thus, they reflect the reference distribution. Secondly, as standardized measures, Z-scores are comparable across age, sex and growth reference measures. Finally, a group of Z-scores can be subject to summary statistics such as mean and Standard Deviation and can be studied as a continuous variable. In addition, Z-scores values can quantify the growth status of children outside of the percentile ranges' (WHO, 1995). Individuals present at more than 2 Standard Deviation in both upper and lower segments are considered to be out of normal range (refer table 3). Both percentiles and Z-scores have few limitations.

Table 3. Z-score classification by nutritional indicator

Z-score classification	Weight-for-age	Height-for-age	BMI-for-age
> +2			Obese
> +1			Overweight
-2 to +1			Normal
< –2	Moderately underweight	Moderately stunted	Thinness
< –3	Severely underweight	Severely stunting	Severely thin

Source: Wang et al., 2012

In this paper, the nutritional status of children was assessed by using various growth measurement 'standards' or 'references' or 'classifications' available nationally and internationally, as well as the appropriateness of these methodologies to measure growth of school-age children. To illustrate this through actual examples, a database of height and weight of rural government school-going children (N=5340) from three districts of Karnataka was used. The database was developed from the study – *'Do we know what they eat and why? A Study on School-level Dietary Adequacy and Impact of Cultural Beliefs on Dietary Choice'* implemented and funded by Azim Premji University. The study was conducted in three districts of Karnataka; Mandya, Mysuru and Yadgir. The conclusions, based on our review and analysis of the different methodologies, have policy implications for the measurement of malnutrition among school-age children in India.

2. An overview of available measures of childhood malnutrition

A review of over 45 published papers (from 2000 to 2016) looking at under and over-nutrition among government school-going children in India (refer annexure) revealed that there is no standardized methodology to measure problematic growth. As there is no such country specific or international 'growth standard' for school-age children, 'growth references' are mistakenly used as a standard by comparing the survey population with the reference population. The review also found evidence of prevalence of malnutrition among school-going children. The methodological review picked up 10 such methods that were used to identify nutritional status of the children. In the international context these include NCHS 1977 reference, CDC 2000 reference, WHO 2007 reference, IOTF 2012 BMI cut-offs, Gomez classification and Waterlow's classification. In the Indian context they include Agarwal standards, ICMR reference values, IAP reference and BMI cut-off for overweight & obesity of Indian children. A new growth reference by Marwaha et al. (2011) for BMI was also reviewed. The review not only documents the methods but also the geographical location, total number of children surveyed (boys and girls), their age group, type of schooling (government or private) and reports the results in terms of prevalence of under-nutrition and over-nutrition.

The methodological review reveals a similar pattern in selecting a particular growth reference and further analyzing deficit nutritional growth. Many studies have made a comparative analysis using mixed-methods; and several have adapted their methodology based on the type of research data in hand. It was also found that a lot of literature reported results using a version of growth references that were 2-3 decades old, though current/revised versions of these references are available. Most importantly, there was no mention of the 'year launched', and that created confusion over which version of growth reference (old or revised) had been used. Most of the literature reported results in percentile except those that used WHO reference. Some studies did not use any references and compared the survey population height, weight data with a national/ international/ reference population of the appropriate age and sex of the children.

2.1 *Definitions of International and growth references for Indian school-age children*

The methodological review prompted me to analyze each of the above identified growth references and document information in the form of a definition that includes year launched, data source, location covered, availability of current/revised version, geographical representation, and various sex and age specific growth charts available and their cut-off values to identify problematic growth among school-age children. The definitions are compiled in table 4.

Table 4. National and International growth references applicable to school-age children and their data source, geographical representation, types of growth charts available

Growth References	Year of Launch	Data Source/ Ethnicity/ Location Covered	Revision/ Simplification/ Normalization	Geographical Representation	Growth Charts Available
Harvard growth curves	1960	White children near Iowa City, Iowa, or in Boston, Massachusetts, United States (1930-1945)	Simplified version of combined sexes by WHO	National (1960) International (1966)	
NCHS	1977	National surveys: NHES – II and III NHANES – I and Fels data as supplementary, United States (1963-1974)	Normalized by CDC/WHO	National (1977) International (1978)	Percentile curves specific to sex and age of 2-18 years: Weight-for-age Stature-for-age and Weight-for-stature
British (U.K.)	1990	Nationally representative data from 11 distinct surveys, United Kingdom (1978-1990)	British 1990 a revised version of Tanner-Whitehouse reference curves 1960	National (for U.K. children)	Percentile curves specific to sex and age of 0-23 years: BMI-for-age
Agarwal et al.	1992	Affluent urban children from 8 Indian States (12 cities) covering all major zones	Adapted by IAP in 2007	National (for Indian children)	BMI criteria Birth – 18 years
CDC	2000	National surveys: NHES – II, III NHANES – I, II, III, United States (1963-1994)	CDC 2000 a revised version of NCHS growth reference	National (for U.S. children)	Percentile curves specific to sex and age of 2-20 years: BMI-for-age Weight-for-age Stature-for-age and Weight-for-stature
WHO	2007	NCHS original statistics data from U.S. population (1963-1974) and smoothed data with WHO growth standard 2006.	WHO 2007 a revised version of NCHS 1977/1978	International	Percentile and Z-score curves specific to sex and age of 5-19 years: BMI-for-age Height-for-age Weight-for-age
Marwaha et al.	2011	Raw data collected from 19 Indian cities from 4 different geographical regions based on children 3-18 years belong to both upper and lower socio economic strata (January 2006 – December 2009)	Not applicable	National (for Indian children)	Sex specific normative charts of 5-18 years: Height Weight BMI percentile
Extended IOTF cut-offs	2012	Nationally representative surveys from Brazil, Great Britain, Hong Kong, Netherlands, Singapore (1978-1993) and U.S. national surveys (1963-1980)	Not applicable	International	Specific to sex and age of 2-18 years: BMI cut-offs for thinness grades (severe, moderate and mild) and overweight, obesity with adult linked BMI.
Khadilkar V. et al.	2012	Urban affluent children from 11 affluent school from 11 cities of India (June 2007 to January 2008)	Not applicable	National (for Indian children)	Specific to sex and age of 5-18 years: Cut-off points for overweight, obesity with adult linked BMI
IAP	2015	Collated data from nine published studies in last 10 years from 14 cities in India (2005-2014)	IAP 2015 a revised version of IAP 2007 growth references	National (for Indian children)	Percentile curves specific to sex and age of 5-18 years: BMI charts, height and weight charts WHO 2006 and IAP 2015 combined height and weight charts for 0-18 years

2.1.1 Stuart/Meredith Growth Charts 1946 and Harvard Growth Curves 1960

The Stuart/Meredith Growth Charts 1946, one among the first growth references in the world, were derived from stature and weight measurements taken of white children living near Iowa City, Iowa, or in Boston, Massachusetts, from 1930 to 1945. The sample size was too small and most of children surveyed were from higher socioeconomic status, making it unrepresentative of United States children (Meredith, 1949). In 1960 and 1970s and following on from the Iowa data, two data sets were frequently used as growth references: the Harvard growth curves from the U.S. and the Tanner growth curves from the U.K. (Tanner et al., 1966). In 1966, WHO established a simplified combined sexes version of Harvard growth curves as international growth reference

(Jelliffe, 1966). This data, derived from the growth of Caucasian (white) children in Boston from 1930-1956, offered the advantages of having been compiled longitudinally (Stuart et al., 1950 cited in de Onis M. and Yip R., 1996). The Harvard growth curves has made a significant contribution towards clinical nutritional assessment; and two of the most famous clinical methods – the Garrow classification and the Gomez classification – both use Harvard 50th percentile as reference value (Dibley et al., 1987).

The Gomez classification was widely used during 1990s in clinical practice of pediatrics to diagnose under-nutrition (weight-for-age) among children. It proposes three categories of malnutrition; Grade I (mild) - 90-75% of standard weight for age, Grade II (moderate) - 75-60% of standard weight for age, Grade III (severe) - less than 60% of standard weight for age. Waterlow's classification of protein energy malnutrition is also largely used in clinical practice to monitor the growth of children in the community (Waterlow, 1997).

2.1.2 National Center for Health Statistics (NCHS) 1977 growth reference

Considering the limitations of the Harvard growth curves, NCHS came up with a new growth reference for the U.S. known as 1977 NCHS curves, which have since been widely used in pediatric practice. This was constructed by pooling three primary data sets from U.S national surveys – the National Health Examination Survey (NHES) II (1963–65) for ages 6–11 years, NHES III (1966–70) for ages 12–17 years, the first National Health and Nutrition Examination Survey (NHANES) I (1971–74) for ages 1–17 years and Fels data (1929-75) for birth to 1 year (as supplemental data from Fels Research Institute in Yellow Springs, Ohio carried out on white middle-class infants of southwestern Ohio). Of 14 sex specific growth charts developed, three charts i.e. weight-for-age (2-18 years), stature-for-age (2-18 years) and weight-for-stature were applicable for the school-age children (Hamil et al., 1977; Kuczmarski et al., 2002). In 1978 Center for Disease Control (CDC) produced a normalized version of 1977 NCHS curves (Dibley et al., 1987) – widely known as the NCHS/WHO, CDC/WHO growth charts/reference – and recommended it for international application (WHO 1978). The major percentiles added to facilitate plotting growth data of the children were 5th, 10th, 25th, 50th, 75th, 90th, and 95th.

The concerns over 1977 NCHS data were mainly concentrated on i) the characteristics of Fels data on infant charts ii) the limited ability to assess size and growth at extremes beyond the 5th and 95th percentiles iii) the absence of weight-for-stature references for adolescents, and iv) the inability to assess growth at ages 18 years and over. (Roche, 1994)

2.1.3 British 1990 growth reference (or U.K. 90)

BMI reference curves for U.K. were developed in 1990 for British children covering the age range of birth to 23 years to replace the Tanner-Whitehouse reference curves, which was based on data that was 30 years old by that time. These were among the first such curves constructed to complement

existing national references. The British growth reference curves were based on nationally representative data collated and obtained from 11 distinct surveys. The data was collected between 1978 and 1990 is presented in table 5. (Cole et al., 1995)

Table 5. Details of the studies providing data for British growth charts

Study	Date	Ages (years)	Region*	Sample size
HUMAG				
Infants	1987	0 - <2	E, W	789
Toddlers	1987	2 - <5	E, W	1014
Boys	1978	5 - <17	E, S	3498
Girls	1986	5 - <16	E, S, W	4280
Men	1984	16 - <23	E, S, W	1748
Women	1987	16 - <23	E, S, W	1057
NSHG	1989-90	4.5 - <12	E, S	10495
Department of Health	1980	16 - <23	E, S, W	1413
Tayside Growth Study	1989-90	4.5 - <14	S	1622
Whittington Hospital	1987-88	33–42 week gestation	E	756
Cambridge Infant Growth Study	1984-90	4 weeks – 2 years	E	3863

* E – England, S – Scotland, W – Wales

Source: Cole et al., 1995

The dataset included in the reference curves provides data on sex, age, height and weight and BMI of 15,636 boys and 14,899 girls for ages between 33 weeks of gestation and 23 years. The reference curves were derived using Cole's LMS (Lambda-Mu-Sigma) method and expressed as nine centiles, (0.4th, 2th, 9th, 25th, 50th, 75th, 91th, 98th and 99.6th) where the two extremes identify the fattest and the thinnest population. The centiles were spaced two thirds of an SD score apart. The BMI reference curves can be used in clinical practice as well as to monitor the size and shape of the U.K. child population. The BMI cut-offs to be used to identify at risk population is shown in table 6.

Table 6. BMI cut-off values used in British 1990 reference curves

	Centiles for clinical assessment	Centiles for monitoring
Underweight	2	2
Overweight	91	85
Obese	98	95

Source: Dinsdale et al., 2011

2.1.4 Centers for Disease Control (CDC) 2000 growth reference (Kuczmarski et al., 2002)

Considering the limitations of NCHS growth reference, and to improve the growth curves based on availability of more recent and comprehensive data from national surveys and statistical smoothing procedures, CDC revised the NCHS growth reference in 2000 for all children in the U.S population, widely known as CDC 2000 growth reference. NHES II and III data remain same and few additional data that pooled for CDC 2000 growth reference were NHANES II (1976-80) for ages 6 months to 17 years and NHANES III (1988-94) for ages 3 months to 10 years presented in table 7. Fels data were used in NCHS for infant was removed.

Table 7. Primary data from U.S national surveys used to construct CDC growth charts

Data Set	Years	Subject*	Sex	Chart**
NHES II	1963 – 65	Age (months): 72.0-145.9	M, F	W, S, BMI
NHES III	1966 – 70	Age (months): 144.0-217.9	M, F	W, S, BMI
NHANES I	1971 – 74	Age (months): 12.0-23.9 12.0-35.9 12.0-281.9 12.0-245.9 18.0-305.9 Length (cm): 65-109 Stature (cm): 77-127	M, F M, F M, F M, F	L HC W W S, BMI WL WS
NHANES II	1976 – 80	Age (months): 6.0-35.9 6.0-281.9 6.0-245.9 18.0-305.9 Length (cm): 65-109 Stature (cm): 77-127	M, F M, F M, F	L, HC W W S, BMI WL WS
NHANES III	1988 – 94	Age (months): 3.0-35.9 2.0-35.9 2.0-71.9 18.0-305.9 18.0-71.9 Length (cm): 65-109 Stature (cm): 77-127	M, F M, F M, F M, F M, F	L HC W S BMI WL WS

* Data from outside the 2-20 year range for the child/adolescent charts were used to improve estimates at the upper and lower age boundaries. Subject ages, shown for growth chart variables, reflect the end points of age ranges for data actually used to construct the smoothed percentile curves.

** W = weight-for-age, S = stature-for-age, BMI = BMI-for-age, L = length-for-age, HC = head circumference-for-age, WL = weight-for-length, WS = weight-for-stature

Source: Kuczmarski et al., 2002

Finally the CDC 2000 reference came up with 14 charts similar to NCHS, and an extra chart for BMI-for-age. CDC 2000 also included an increase in the upper age limit by 2 years (from 18 to 20 years) for weight-for-age and stature-for-age. Of a total of 15 growth charts, four charts allow assessment of nutritional attainment of school-age children in terms of under-nutrition and over-nutrition. The 3rd and 97th percentile added in the CDC revised charts and the major percentiles used in NCHS were retained. An extra 85th percentile was added to BMI-for-age and weight-for-stature growth charts to identify overweight children or those at risk of being overweight.

2.1.5 WHO 2007 reference for age 5-19 years

Considering the drawbacks of 1977 NCHS international growth reference in terms of age restriction, distribution range and ineffectiveness of assessing childhood obesity, WHO proceeded to reconstruct the NCHS growth reference to develop a single international growth reference in 2007 for school-age children from 5–19 years of age, based on the original NCHS statistics data (5–24 years). This is appropriate for both clinical and public health applications. However, a different statistical method was used to smooth data pertaining to the 0–5 years segment in the WHO growth standard 2006 (Turck, 2013). WHO 2007 growth reference for 5–19 years was constructed by pooling three sets of data from U.S. population (Hamill et al., 1977); the first two datasets from NHES Cycle II (6–11 years) and Cycle III (12–17 years) and the third one, NHANES Cycle I (birth to 74 years), from which only data for the 1 to 24 years age range was used. The data from WHO Child Growth Standard's cross sectional sample (18-71 months) was merged with the NCHS final sample to develop the WHO 2007 reference. The final sample used for fitting the growth curves included 30907 observations (15537 boys, 15370 girls) for the height-for-age curves, 30100 observations (15136 boys, 14964 girls) for the weight-for-age curves, and 30018 observations (15103 boys, 14915 girls) for the BMI-for-age curves (Mercedes et al., 2007).

According to WHO recommendations, malnutrition among school-aged children can be measured by using three gender and sex specific nutritional indicators i.e. weight-for-age (underweight status), height-for-age (stunted status) and BMI-for-age (low BMI-for-age status). Overweight and obese status can be measured using BMI-for-age. Underweight status can be measured only till 10 years of age.

'The WHO has recommended cut-off points for overweight and obesity based on the BMI-for-age Z-scores. With the smoothing methods, it showed that the BMI-for-age Z-score = 1 at 19 years was 25.4 for boys and 25.0 for girls, which equals or is close to the WHO BMI cut point of 25 used in adults. Thus, the reference curve of Z-score = 1 was recommended to classify overweight, while that of Z-score > 2 for classifying obesity based on the same idea. BMI-for-age Z-score < -2 and < -3 were set as the cut-points for thinness and severe thinness, respectively' (WHO MGRSG, 2006b).

The WHO AnthroPlus software (WHO, 2009) is freely available for global application of the WHO reference 2007 for 5-19 years to monitor the growth of school-age children and adolescents. To show consistency with the WHO Anthro software for under five years, AnthroPlus includes the three indicators that apply to school-age children i.e. weight-for-age, height-for-age and BMI-for-age. The software provides Z-scores for each indicator, and the nutritional status can be detected based on the cut-off values.

Table 8. WHO classification based on anthropometry and cut-offs

Classification		Age 61 Months to 19 Years Indicator and Cut-off
Based on BMI	Overweight	BMI-for-age >1 SD (equivalent to BMI 25Kg/m2 at 19 years)
	Obese	BMI-for-age >2 SD (equivalent to BMI 30Kg/m2 at 19 years)
	Thin	BMI-for-age <-2 to -3 SD
	Severely thin	BMI-for-age <-3 SD
Based on height and weight	Stunted	Height-for-age <-2 to -3 SD
	Severely stunted	Height-for-age <-3 SD
	Underweight	Weight-for-age (up to 10 years) <-2 SD to -3 SD
	Severely underweight	Weight-for-age (up to 10 years) <-3 SD

Table 8a

Z-score and percentile equivalence	
Z-score	**Percentile**
-3	0.1
-2	2.3
-1	15.9
+1	84.1
+2	97.7
+3	99.9

Source: Mercedes de Onis, ECOG Obesity e-book

2.1.6 Nation-wide reference data for Height, Weight and BMI of Indian school children

Growth reference for Indian children and adolescents was constructed by Marwaha from a nationally representative cross-sectional evaluation of anthropometry parameters (height, weight and BMI) from Indian school children (both boys and girls) of age group 3-18 years, studying in government and private schools located in 19 cities from 4 different geographical zones (north, south, east and west) during January 2006 to December 2009 (Marwaha et al., 2011). The children were selected from both upper and lower socio-economic strata, differentiated on the basis of fee-paying and non-fee-paying. Of 1,06,443 children 42,214 were from lower strata and 64,629 from upper strata, height, weight and BMI percentile charts were constructed using LMS method. The smoothed percentile curves were drawn from children belonging to upper strata, in view of the gross discrepancy between the two strata. The sex and age specific curves were expressed in nine percentiles, 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th, and 97th. The limitations were i) lack of longitudinal data ii) year-wise grouping of children and iii) pubertal assessment. The significant difference of this study in comparison with other Indian studies was that it showed higher values.

2.1.7 Extended International Obesity Task Force (IOTF) cut-offs

IOTF BMI cut-offs to measure thinness, overweight and obesity among children aged 2-18 years are internationally applicable. It obtained data on BMI for children from six large nationally representative cross sectional surveys on growth presented in table 9.

Table 9. Six nationally representative datasets of body mass indices in childhood used to construct IOTF BMI cut-off points

Country	Year	Description	Males		Females	
			Age range	Sample size	Age range	Sample size
Brazil	1989	Second national anthropometric survey	2 – 25	15947	2 – 25	15859
Great Britain	1978–93	Data pooled from five national growth surveys	0 – 23	16491	0 – 23	15731
Hong Kong	1993	National growth survey	0 – 18	11797	0 – 18	12168
Netherlands	1980	Third nationwide growth survey	0 – 20	21521	0 – 20	20245
Singapore	1993	School health service survey	6 – 19	17356	6 – 20	16616
United States	1963-80	Data pooled from four national surveys	2 – 20	14764	2 – 20	14232

Source: Cole et al., 2000

Four of the datasets came from one-off surveys, while British and United States data were pooled from surveys collected over a period of time. IOTF BMI cut-offs is also linked with WHO recommended adult cut-off points of 16 (thinness grade-III or severe), 17 (thinness grade-II or moderate) and 18.5 (thinness grade-I or mild) at age 18 to measure thinness; and adult overweight and obesity cut-off points of 25kg/m^2 and 30kg/m^2 to measure overweight and obesity. The BMI cut-off points for thinness and overweight & obesity are provided in at age 18 years for Indian boys and girls 2012 the cited reference (Cole et al., 2000; Cole et al., 2007).

2.1.8 Age specific BMI cut-off values for risk of overweight and obesity corresponding to adult equivalent BMI of 23 and 28 kg/m^2 at age 18 years for Indian boys and girls 2012

Khadilkar conducted a study to construct age and sex specific adult equivalent BMI cut-offs for Indian children, based on a reference population of urban affluent children measured during the period June 2007 to January 2008 (Khadilkar et al., 2012). Data collected on 18,666 children (10,496 boys and 8,170 girls) from 11 affluent schools of 10 cities (Delhi, Chandigarh, Chennai, Bangalore, Kolkata, Mumbai, Pune, Baroda, Hyderabad and Raipur) representing 5 geographical zones of India (North, South, East, West, and Central). Children were measured by their height, weight and BMI was calculated using the standard formula. As IOTF proposed that adult cut-off points must be linked to BMI percentiles for children to provide child cut-off points (Bellizzi et al., 1999), the study (Khadilkar et al., 2012) suggested lower BMI cut-offs of 23 and 28 kg/m^2 for overweight and obesity in Asian populations as compared to internationally recognized cut-off points of 25 and 30 kg/m^2 for overweight and obesity in adults. By using LMS method, growth reference curves were constructed.

This provides cut-off points based on five percentiles (3rd, 25th, 50th, 85th and 95th) with two additional percentiles corresponding to a BMI of 23 and 28 kg/m^2 at 18 years. BMI of 23 kg/m^2 at 18 years age in boys corresponds to the 64th percentile, and in girls to the 63rd percentile. A BMI of 28 kg/m^2 at 18 years age is on the 89th percentile in both boys and girls. It does not provide SD scores but it is possible that LMS curves convert measurements into exact SD scores using standard formula.

2.1.9 Revised Indian Academy of Pediatrics (IAP) growth references for 5-18 years old Indian children 2015

The effort to construct a growth chart for Indian children was started in the late 1950's. The Indian Council for Medical Research (ICMR) undertook a nation-wide cross sectional study during 1956 and 1965 to establish Indian reference charts. The measurements were made on children of the lower socio-economic class and hence cannot be used as a reference standard (Khadilkar et al., 2007). The growth charts compiled by Agarwal, published in 1992 and 1994 are based on measurements taken between the period 1989-91 of affluent urban children (12,899 boys and 9,951 girls) from all major geographical zones of India covering 8 States (Agarwal et al., 1992). These charts provide information on growth from birth to 18 years and were then adapted by the Indian Academy of Pediatrics for growth monitoring in 2007.

In 2015, IAP revised its growth chart for height, weight and BMI to replace the 2007 IAP charts for the assessment of growth of 5-18 years old Indian children. The revised IAP growth charts were constructed on 33,148 children based on the collated national data and from 9 published studies in the previous 10 years. The 9 published studies provided raw data on height, weight, age, sex and socio-economic class. Data from 14 cities in India were collated; these are Agartala, Ahmedabad, Chandigarh, Chennai, Delhi, Hyderabad, Kochi, Kolkata, Madurai, Mumbai, Mysore, Pune, Raipur and Surat. Of 33,148 children, 7,227 (4,514 boys, 2,713 girls), 7,835 (4,263 boys, 3,572 girls), 4,408 (2,131 boys, 2,277 girls), 10,474 (5,473 boys, 5,001 girls), 3,204 (1,789 boys, 1,415 girls) were from North, South, East, West and Central zones respectively. Age and sex specific IAP growth charts on height, weight and BMI are available. The BMI chart follows the same method as International Obesity Task Force (IOTF). It provides cut-offs based on percentiles (3rd, 5th, 10th, 25th, 50th, 23rd and 27th) and Z-score values. The 3rd percentile is used to define thinness, 23rd adult equivalent as overweight and 27th adult equivalent as obesity cut-offs. The BMI cut-off points are given in the cited reference (Khadilkar et al., 2015).

The above definitions provide clear evidence on growth references that are applicable internationally and nationally, but still there are limitations. There are also country specific growth charts available such as Canada, China, Europe and The Netherlands. Many of these country specific growth charts such as U.K. charts were adapted from WHO growth charts and have not been declared as 'international'.

3. Differences in nutritional outcomes using International and Indian growth references

The height, weight and BMI of the surveyed children (N=5,340) are compared with the reference population and growth references discussed above. As presented in Table 4, nutritional indicator BMI-for-age or BMI cut-offs are common among all growth references and have therefore been considered for this comparative analysis to observe the differences in nutritional outcome and pattern that emerges in measuring under and over-nutrition in surveyed children.

First, the height, weight and BMI of the surveyed population are compared with the Indian Council of Medical Research (ICMR) sex and age specific reference values (ICMR, 2002; GoI, 1998).

Table 10. Comparison of mean height, weight and BMI with ICMR reference value: Boys

Age	N	Surveyed Children: Boys			ICMR Reference Values: Boys		
		Mean weight (Kg)	Mean height (Cm)	Mean BMI	Mean weight (Kg)	Mean height (Cm)	Mean BMI
5 years	181	16.1	107.9	14.0	18.2	111.5	14.6
6 years	458	17.1	112.3	13.5	20.4	118.5	14.5
7 years	533	18.6	116.8	13.6	22.7	124.3	14.7
8 years	519	20.6	121.9	13.8	25.2	130.1	14.9
9 years	506	22.7	126.9	14.1	28	134.6	15.5
10 years	296	24.5	130.3	14.4	30.8	140	15.7
11 years	37	25.2	132.7	14.3	34.1	144.8	16.3

Note: Data for <5 years and >11 years were removed due to N=<10.

Table 11. Comparison of mean height, weight and BMI with ICMR reference value: Girls

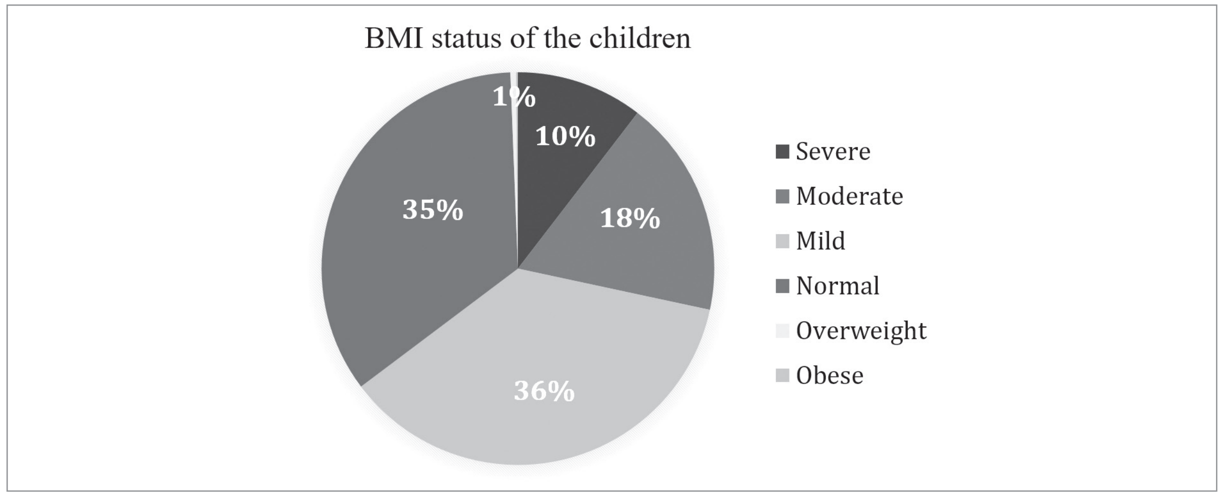
Age	N	Surveyed Children: Girls			ICMR Reference Values: Girls		
		Mean weight (Kg)	Mean height (Cm)	Mean BMI	Mean weight (Kg)	Mean height (Cm)	Mean BMI
5 years	231	15.7	107.2	13.7	17.7	111	14.4
6 years	515	16.7	110.9	13.6	20	117.5	14.5
7 years	555	18.7	116.3	13.8	22.3	123.6	14.6
8 years	518	20.5	121.2	13.9	25	129.2	15
9 years	569	22.7	126.1	14.2	27.6	135	15.1
10 years	358	24.5	129.9	14.5	31.2	140	15.9
11 years	35	26.7	133.2	15.0	34.8	145.3	16.5

Note: Data for <5 years and >11 years were removed due to N=<10.

It is clear that the mean height, weight and BMI of boys and girls in the surveyed population are far below than the age appropriate reference value. The mean height and weight is increasing with age, but the improvement of BMI is very slow or stagnant.

Second, IOTF BMI cut-off values were used to assess thinness, overweight and obesity among surveyed children. The IOTF overweight and obesity cut-offs was then compared with the cut-offs for Indian children proposed by Khadilkar (Khadilkar et al., 2012). The findings are presented below:

Figure 1. Prevalence of thinness, overweight and obesity using BMI IOTF cut-offs



Overall, 64 percent children were suffering from various grades of thinness; 10 percent being severely thin, 18 percent moderately thin and 36 percent at risk of being categorized as mild grade of thinness. About 11 percent of boys were severely thin but a higher percentage of girls were within the range of moderate and mild grade of thinness: 17 and 36 percent respectively. Overweight and obesity reported was very low about less than one percent (refer figure 1).

Table 12. Prevalence of thinness by sex and age group (%)

Age group	Male				Female			
	Severe	Moderate	Mild	Normal	Severe	Moderate	Mild	Normal
< 5 years			25.0	75.0	40.0	40.0		20.0
5-7 years	11.9	18.3	35.1	34.3	9.1	20.0	39.0	31.7
8-11 years	10.5	15.3	36.5	36.7	10.3	18.4	35.5	35.1
> 11 years			22.2	77.8	9.1	18.2		63.6

The prevalence of thinness was higher in the 5-7 years age group for both boys and girls. More children belonged to the mild grade – at risk of falling into moderate or severe – and needed urgent attention (refer table 12).

Table 13. Comparison between IOTF BMI cut-off points and BMI cut-off points for Indian children by gender and age group of the children (%)

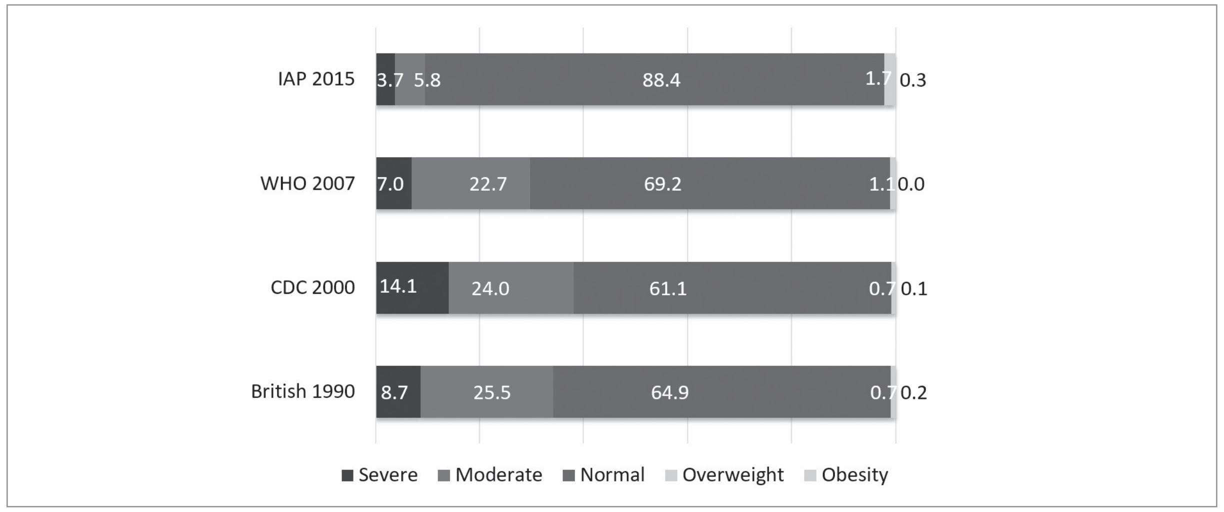
Gender	Age group	IOTF BMI cut-off points		BMI cut-off points for Indian children	
		Overweight	Obese	Overweight	Obese
Male	< 5 years	0.00	0.00		
	5-7 years	0.30	0.20	1.40	0.30
	8-11 years	0.80	0.10	1.50	0.30
	> 11 years	0.00	0.00	0.00	0.00
Female	< 5 years	0.00	0.00		
	5-7 years	0.20	0.00	4.80	0.40
	8-11 years	0.50	0.20	2.60	0.50
	> 11 years	0.00	0.00	0.00	0.00

Note: BMI cut-off points available for Indian children from age 5 years to 18 years.

There is a very minor difference in the prevalence of overweight and obesity (refer Table 13) based on Indian and International BMI cut-offs. The prevalence is slightly higher for Indian cut-offs compared to international cut-offs, irrespective of sex and age of the children.

Thirdly, a comparative analysis of BMI-for-age was performed using four growth references; British, CDC, IAP and WHO. Z-score was obtained from LMS macro (by using ImsGrowth program version 2.12 compiled on 12 December, 2005 by Tim Cole and Huiqi Pan) and then analysis was performed (Fig. 2). The findings reveal that overall prevalence of under-nutrition (low BMI-for-age) is over estimated using International references as compared to Indian references.

Figure 2. Comparison of nutritional status (%) of children using International and Indian growth references



The prevalence of under-nutrition is higher in CDC 2000 (38 percent) and lower in IAP 2015 (10 percent). WHO 2007 shows 30 percent prevalence of under-nutrition. Overweight and obesity reported is very low; less than one percent. British 1990 and CDC 2000 growth reference is not applicable for Indian children and is primarily considered for comparative purposes.

Table 14. Comparison of BMI of the children by gender and age using International and Indian growth references in %

Growth References		Male				Female			
		< 5 Years	5-7 Years	8-11 Years	> 11 Years	< 5 Years	5-7 Years	8-11 Years	> 11 Years
British 1990	Severe	0.0	13.9	9.7	33.3	0.0	5.8	6.1	0.0
	Moderate	75.0	25.5	27.3	11.1	20.0	23.8	25.3	9.1
	Normal	25.0	59.8	61.9	55.6	80.0	69.8	67.5	90.9
	Overweight	0.0	0.5	0.9	0.0	0.0	0.6	0.7	0.0
	Obesity	0.0	0.3	0.2	0.0	0.0	0.1	0.3	0.0
CDC 2000	Severe	0.0	21.1	15.4	33.3	0.0	13.2	8.3	0.0
	Moderate	75.0	24.4	27.1	11.1	20.0	21.4	23.2	9.1
	Normal	25.0	53.8	56.9	55.6	80.0	64.4	67.6	90.9
	Overweight	0.0	0.6	0.5	0.0	0.0	0.8	0.8	0.0
	Obesity	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.0
WHO 2007	Severe	0.0	8.8	10.2	33.3	0.0	4.1	5.2	0.0
	Moderate	0.0	24.0	28.6	11.1	0.0	18.0	20.6	9.1
	Normal	100.0	66.4	60.0	55.6	100.0	76.8	73.0	90.9
	Overweight	0.0	0.9	1.1	0.0	0.0	1.2	1.2	0.0
IAP 2015	Severe	0.0	3.4	4.6	11.1	0.0	3.1	3.5	0.0
	Moderate	0.0	6.7	6.9	22.2	0.0	4.5	5.3	0.0
	Normal	0.0	88.5	87.1	66.7	0.0	89.2	89.2	100.0
	Overweight	0.0	0.9	1.1	0.0	0.0	3.0	1.7	0.0
	Obese	0.0	0.5	0.2	0.0	0.0	0.2	0.3	0.0

The pattern emerging from Table 14 illustrates the following:

(i) British 1990: Boys are more malnourished than girls; 38 vs. 30 percent. Younger boys (of 5-7 years) are more malnourished than older boys (of 8-11 years). In contrast, older girls are more malnourished than younger ones.

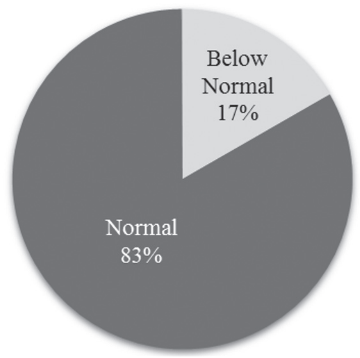
(ii) CDC 2000: Boys are more malnourished than girls; 44 vs. 33 percent. Younger boys and girls are more malnourished than older boys and girls.

(iii) WHO 2007: Boys are more malnourished than girls; 36 vs. 24 percent. The prevalence of malnourished children (for both boys and girls) increases with age.

(iv) IAP 2015: The prevalence of under-nutrition and over-nutrition reported is very low. About 80-85 percent children are normal.

Finally the Marwaha reference was applied to the height and weight data (Marwaha et al., 2011). The BMI percentile cut-offs were used to categorize children into below normal (< 3 percentile) and above normal (>97 percentile). 17 percent of the children were found malnourished.

Figure 3. Nutritional status of children by using Marwaha et al., 2011 reference



The comparative analysis clearly shows that the nutritional outcome of similar group of children varies with the application of each set of growth references. From this it is very difficult to take a stand on any single growth reference as the most appropriate one to measure the nutritional outcome of Indian school-age children, given its limitations and global representation.

4. Discussion

There is controversy over the application of appropriate growth reference to measure under-nutrition and over-nutrition mainly because (i) there is a lack of an established growth standard for school-age children (ii) the definition of all the growth references provides different perspectives and therefore the nutritional outcome also varies.

This throws up many challenging questions.

a. What could be a nationally/internationally representative sample? For example, IAP included North East zone (Agartala) but Marwaha et al. (2011) reference does not include the North East zone or mention any areas covered in this zone. The IAP reference was constructed by pooling raw data from 9 published studies over 10 years but Marwaha et al. (2011) collected raw data over 2 years period. The sample size for constructing growth charts of Marwaha et al. (2011) reference is much higher than the IAP reference; 64,629 vs. 33,148 children respectively. Data used to construct growth charts for growth references such as NCHS, CDC and WHO, which were declared for international application, do not have global representation. How can it then provide accurate nutritional outcome for Indian school-age children?

b. Who are the affluent healthy children? The development of growth charts were mainly confined to the children belonging to higher social-economic strata. These higher social-economic strata children represented cities or urban areas. Therefore the measures adapted by the growth references to select and inclusion of affluent healthy children into the sample for constructing growth charts are not clear.

c. In public health, Z-score is a preferable expression of nutritional indices in measuring child growth, but with the exception of WHO, national and international growth references have not constructed growth chart with Z-score. Given the difficulty in calculating Z-score (especially understanding the concept and variation between Z-score and percentile calculation), percentile charts available readily were used frequently by the researchers. There are inconsistencies in applying appropriate expression of nutritional indices for public health interventions in terms of percentile and Z-score.

d. Given the different perspectives in defining growth references, can the nutritional outcome measured by applying different growth references be compared with each other? The comparative analysis showed many inconsistencies in terms of underestimation and over estimation of nutritional outcome.

e. How does a researcher select a growth chart (or growth reference) to analyze nutritional status of a particular group of school-age children? The methodological review of the literature and even definitions of these growth references do not provide clarity on its correct application to a given population.

There is an urgency to tackle malnutrition among school-age children in India. Given the existence of more than one national and international level growth reference, the nutritional outcome does not validate the appropriateness of its application to a given population. A growth standard therefore may be the answer (i) to generate data on prevalence of malnutrition among school-age children through national level surveys like National Family Health Survey (ii) to introduce a regular growth monitoring system in schools (iii) to promote research with a validated result that can be compared with prevalence of district, state and national level data and provide an indication on growth pattern (iv) to strengthen the nutritional aspects of the mid-day meal for better nutritional outcome. Though this paper is focused on malnutrition, it simultaneously provides similar importance to over growth. A growth Standard therefore fills up such gaps in measuring double burden of malnutrition i.e. under-nutrition and over-nutrition.

References

Abraham S. B., Chauhan R. C., Rajesh M., Purty A. J. and Singh Z. (2015). Nutritional status and various morbidities among school children of a coastal area in South India. *International Journal of Research in Medical Sciences* 3(3), 718-722.

Agarwal D. K., Agarwal K. N., Upadhyay S. K., Mittal R., Prakash R. and Rai S. (1992). Physical and sexual growth pattern of affluent Indian children from 5-18 years of age. *Indian Pediatrics* 29, 1203-82.

Agarwal K. N., Saxena A., Bansal A. K. and Agarwal D. K. (2001). Physical Growth assessment in adolescence. *Indian Pediatrics* 38, 1217-1235.

Ashok N. C., Kavitha H. S. and Kulkarni P. (2014). A comparative study of nutritional status between government and private primary school children of Mysore city. *International Journal of Health & Allied Sciences* 3(3), 164-169.

Bandikolla V. (2016). A study on nutritional assessment of school going children. *World Journal of Clinical Pharmacology, Microbiology and Toxicology* 2(1), 01-03.

Banerjee S., Dias A., Shinkre R. and Patel V. (2011). Under-nutrition among adolescents: A survey in five secondary schools in rural Goa. N*ational Medical Journal of India* 24, 8-11.

Bellizzi M. C. and Dietz W. H. (1999). Workshop on childhood obesity: Summary of the discussion. *American Journal of Clinical Nutrition* 70, 173-5.

Bharati P., Itagi S. and Megeri S. N. (2005). Anthropometric measurements of school children of Raichur, Karnataka. *Journal of Human Ecology* 18, 177-9.

Bhattacharya A., Basu M., Chatterjee S., Misra R. N. and Chowdhury G. (2015). Nutritional status and morbidity profile of school going adolescents in a district of West Bengal. *Muller Journal of Medical Sciences and Research* 6(1), 10-15.

Bose K., Bisai S. and Mukherjee S. (2007). Anthropometric characteristics and nutritional status of rural school children. *Internet Journal of Biological Anthropology* 2(1).

Chakraborty R. and Bose K. (2009). Very high prevalence of thinness using new international body mass index cut off points among 5-10 year old school children of Nandigram, West Bengal, India. *Journal of Research in Medical Sciences* 14, 129-133.

Chandra K. R., Padennavar U. M., Sadashivappa T. and Prabhakara G. N. (2006). Nutrition assessment survey of schoolchildren of Dharwad and Haliyal Taluks, Karnataka state, India. *Kathmandu University Journal of Science Engineering and Technology* 2, 1-19.

Chandramohan S., Khan J. and Raj R. J. (2015). Nutritional status assessment of primary school children in Udupi District Karnataka: A cross sectional study. *International Journal of Applied Research and Studies* 4(3).

Cogill B. (2003). Anthropometric indicators measurement guide. https://www.fhi360.org/ (accessed on 27 April, 2018).

Cole T. J., Freeman J. V. and Preece M. A. (1995). Body mass index reference curves for the UK, 1990. *Archives of Disease in Childhood* 73, 25-9.

Cole T. J., Bellizzi M. C., Flegal K. M. and Dietz W.H. (2000). Establishing a standard definition for child overweight and obesity worldwide: International survey. *British Medical Journal* 320, 1240–3.

Cole T. J., Flegal K. M., Nicholls D. and Jackson A. A. (2007). Body mass index cut-offs to define thinness in children and adolescents: International survey. *British Medical Journal* 335, 194-202.

Subhaprada S. C. (2015). Nutritional status of government primary school children in an urban slum, Kurnool, Andhra Pradesh. *International Journal of Current Medical and Applied Sciences* 6(3), 167-170.

Dambhare D. G., Bharambe M. S., Mehendale A. M. and Garg B. S. (2010). Nutritional status and morbidity among school going Adolescents in Wardha, a Peri-Urban area. *Online Journal of Health and Allied Sciences* 9(2).

Das S., Addhya D. and Chakrabarty F. (2012). Prevalence of thinness among 6-12 years rural children of Kharagpur. *Antrocom Online Journal of Anthropology* 8, 1973–2880.

De Onis M. and Yip R. (1996). The WHO Growth Chart: Historical considerations and Current Scientific Issues. in Walter P. and Basel J. C. Bibliotheca Nutritio et Dieta 53, 74-89.

de Onis M., Onyango A. W., Borghi E., Siyam A., Nishida C. and Siekmann J. (2007). Development of a WHO growth reference for school-aged children and adolescents, Bulletin of the World Health Organization Sep. 85(9), 660-7.

de Onis M. World Health Organization Reference Curves. European Childhood Obesity Group. http://ebook.ecog-obesity.eu/chapter-growth-charts-body-composition/world-health-organization-reference-curves/?utm_source=text&utm_medium=article-link&utm_campaign=ebook-en (accessed on 27 April, 2018).

Deb P. and Dhara P. C. (2013). Anthropometric Measurements and Under-nutrition: A Case on School Children of South Tripura, India. *Journal of Life Sciences* 5(1), 47-51.

Dhanasekaran J., Mayanathan J. and Ponnappan A. (2013). Prevalence of underweight among government primary school children of Chennai. *Academic Medical Journal of India* 1(1), 1-4.

Dibley M. J., Goldsby J. B., Staehling N. W. and Trowbridge F. L. (1987). Development of normalized curves for the international growth reference: Historical and technical considerations. *American Journal of Clinical Nutrition* 46, 736-48.

Dinsdale H., Ridler C. and Ells L. J. (2011). A simple guide to classifying body mass index in children. Health Economics Research Centre, University of Oxford. https://www.herc.ox.ac.uk/downloads/health_datasets/browse-data-sets/the-national-obesity-observatory-for-england (accessed on 27 April, 2018)

Fazili A., Mir A. A., Pandit I. M., Bhat I. A., Rohul J. and Shamila H. (2012). Nutritional status of school age children (5-14 years) in a rural health block of North India (Kashmir) Using WHO Z-Score System. *Online Journal of Health and Allied Sciences* 11(2).

Government of India. (1998). India Nutrition Profile. Ministry of Women and Child Development. GoI.

Government of India. (2013). National Policy for Children 2013. Ministry of Women and Child Development. GoI.

Hamil, and Peter V. V. (1977). NCHS Growth curves for children birth – 18 years, *Vital and Health statistics* 11(165), Data from the National Health Survey; no. 165. U. S. Department of Health, Education and Welfare publication, Public Health Services, 78-1650.

Hamill P. V., Drizd T. A., Johnson C. L., Reed R. B. and Roche A. F. (1977). NCHS growth curves for children birth-18 years: United States. National Center for Health Statistics.

Hasan I., Zulkifle M. and Ansari A. H. (2011). An assessment of nutritional status of the children of government Urdu higher primary schools of Azad Nagar and its surrounding areas of Bangalore. *Scholars Research Library, Archives of Applied Science Research* 3(3), 167-176.

Hasan I., Zulkifle M., and Ansari A. H. (2013). Prevalence of underweight among school children of government Urdu higher primary schools of Azad Nagar and its surrounding areas of Bangalore. *International Research Journal of Medicine and Medical Sciences* 1(1), 8-12.

Indian Council of Medical Research. (2002). Diet and nutritional status of rural Population. National Nutrition Monitoring Bureau. Technical Report No 21, National Institute of Nutrition. ICMR.

Iyer U. M., Bhoite R. M. and Roy S. (2011). An exploratory study on the nutritional status and determinants of malnutrition of urban and rural adolescent children (12-16) years of Vadodara city. *International Journal of Applied Biology and Pharmaceutical Technology* 2(1), 102-107.

Jelliffe D. B. (1996). The assessment of the nutritional status of the community. World Health Organization Monograph Series; 53.

Joice Y. S., Velavan A., Natesan M., Singh Z., Purty A. J. and Hector H. (2013). Assessment of nutritional status and morbidity pattern among school children of rural Puducherry. *Academic Medical Journal of India* 1(1).

Kamath R., Jakkula R. P. and Kumar S. (2015). Nutritional status assessment of school children in Bellary district, Karnataka, *Journal of Dr. NTR University of Health Sciences* 4(1), 13-16.

Khadilkar V. V., Khadilkar A. V., Choudhury P., Agarwal K. N., Ugra D. and Shah N. K. (2007). IAP growth monitoring guidelines for children from birth to 18 years. *Indian Pediatrics* 44, 187-197.

Khadilkar V. V., Khadilkar A. V., Cole T. J. and Sayyad M. G. (2009). Cross sectional growth curves for height, weight and body mass index for affluent Indian children, 2007. *Indian Pediatrics* 46, 477-89.

Khadilkar V. V., Khadilkar A. V. and Chiplonkar S. A. (2010). Growth performance of affluent Indian preschool children: A comparison with the new WHO growth standard. I*ndian Pediatrics* 47, 869-72.

Khadilkar V. and Khadilkar A. (2011). Growth charts: A diagnostic tool. I*ndian J Endocrinology and Metabolism* 15, 166-71.

Khadilkar V. V., Khadilkar A. V., Borade A. B. and Chiplonkar S. A. (2012). Body Mass Index cut-offs for screening for childhood overweight and obesity in Indian Children. *Indian Pediatrics* 49, 29-43.

Khadilkar V., Yadav S., Agarwal K. K., Tamboli S., Banerjee M., Cherian A., Goyal J. P., Khadilkar A., Kumaravel V., Mohan V., Narayanappa D., Ray I. and Yewale V. (2015). Revised IAP Growth Charts for Height, Weight and Body Mass Index for 5- to 18- year-old Indian Children. **Indian Pediatrics** 52, 47-55.

Kuczmarski R. J., Ogden C. L. and Guo S.S. et al. (2002). 2000 CDC growth charts for the United States: Methods and development. *Vital Health Statistics* 11(246). Department of Health and Human Services, National Center for Health Statistics.

Kumar P. C., Reddy S., Geetha K. M., Chatterjee A. and Vishnupriya. (2016). Assessment of nutritional status of the government primary school children in slum area of Bengaluru, Karnataka. *American Journal of PharmTech Research* 6(3), 184-189.

Kumar R., Sangwan L., Peter R. and Malik I. (2014). Anthropometric characteristics and nutritional status of rural primary school children in Fatehabad city in Haryana. *International Journal of Basic and Applied Medical Sciences* 4(1), 322-326.

Kumaravel V., Shriraam V., Anitharani M., Mahadevan S., Balamurugan A. N., and Sathiyasekaran B. W. C. (2016). Are the current Indian growth charts really representative? Analysis of anthropometric assessment of school children in a South Indian district. *Indian Journal of Endocrinology and Metabolism* 18(1), 56-62.

Malina R. M., and Katzmarzyk P. T. (1999). Validity of the body mass index as an indicator of the risk and presence of overweight in adolescents. *American Journal of Clinical Nutrition* 70, 131-6S.

Malpani A. K., Sarat S., Shivanand V. H. and Ade A. (2014). Prevalence of malnutrition among school children in rural area of north Karnataka region. *Indian Journal of Pharmacy Practice* 7(2), 33-36.

Manna P.K., De D., Bera T.K., Chatterjee K. and Ghosh D. (2011). Anthropometric assessment of physical growth and nutritional status among school children of North Bengal. *Kamla-Raj Anthropologist* 13(4), 299-305.

Marwaha R. K., Tandon N., Ganie M. A., Kanwar R., C. Shivaprasad, Sabharwal A., Bhadra K. and Narang A. (2011). Nationwide reference data for height, weight and body mass index of Indian schoolchildren. *National Medical Journal of India* 24, 269-77.

Meredith H. V. (1949). A 'physical growth record' for use in elementary and high schools. *American Journal of Public Health* 39, 878-885.

Navaneethan P., Kalaivani T., Rajasekaran C. and Sunil N. (2011). Nutritional status of children in rural India: A case study from Tamil Nadu, first in the world to initiate the Mid-Day Meal scheme. *Health* 3(10), 647-655.

Nigudgi S. R., Boramma G., Shrinivasreddy B. and Kapate R. (2012). Assessment of nutritional status of school children in Gulbarga City. *Journal of Pharmaceutical and Biomedical Sciences* 21, 1-3.

Pal D., Kanungo S., Bal B., Bhowmik K., Mahapatra T. and Sarkar K. (2016). Malnutrition Scenario among School Children in Eastern-India-an Epidemiological Study. *Epidemiology (Sunnyvale)* 6, 228.

Roche A. F. (1994). Executive summary of the growth chart workshop, December 1992. U.S. Department of Health and Human Services, Center for Disease Control and Prevention. https://www.cdc.gov/nchs/data/misc/growork.pdf (accessed on 27 April, 2018).

Ruchika H., Faizan A., Kesari K. K. and Prasad R. (2008). Assessment of nutritional status of 7-10 years school going children of Allahabad District: A Review. *Middle-East Journal of Scientific Research.* 3(3), 109-115.

Saluja N., Bhatngar M., Garg S. K., Chopra H. and Bajpai S. K. (2010). Nutritional status of urban primary school children in Meerut. *Internet Journal of Epidemiology* 8, 1.

Sangwan L., Kumar R., Peter R. and Arun P. (2014). Anthropometric characteristics and nutritional status of primary school children in Fatehabad city in Haryana. **International Journal of Basic and Applied Medical Sciences** 4(2), 339-343.

Sasikala P. (2016). Assessment of nutritional status of boys and girls in government school children in Rompicherla Mandal, Andhra Pradesh, India. *Journal of Education and Practice* 7(10).

Sati V. and Dahiya S. (2012). Nutritional assessment of rural school- going children (7-9 Years) of Hisar District, Haryana. *Scientific Reports* 1, 363-368.

Selvaraj V., Sangareddi S., Velmurugan L., Muniyappan U. and Anitha F. S. (2016). Nutritional status of adolescent school children in a semi-urban area based on anthropometry. *International Journal of Contemporary Pediatrics* 3(2), 468-472.

Semwal J., Srivastava A. K., Gupta S., Kishore S., and Chandra R. (2006). Nutritional status of school children in rural areas of Dehradun district. *Indian Journal of Preventive and Social Medicine* 37(1 & 2), 76-81.

Shashank K. J. and Chethan T. K. (2016). Nutritional status of school going children between the age group of 6-12 years in rural area of Bijapur district. *National Journal of Community Medicine* 7(5).

Shivaprakash N. C. and Joseph R. B. (2014). Nutritional status of rural school-going children (6-12 Years) of Mandya District, Karnataka. *International Journal of Scientific Study* 2(2).

Singh A. P. and Sekhon J. (2015). Anthropometric estimates of nutritional status of school going children of Sri Muktsar Sahib (Punjab) India. *Human Biology Review* 4(1), 74-83.

Singh J. P., Kariwal P., Gupta S. B., Singh A. K. and Imtiaz D. (2014). Nutritional status and morbidity among school going children: A scenario from rural India. *Scholars Journal of Applied Medical Sciences* 2(1D), 379-383.

Sridhar N. L., Srinivas M., Seshagiri G. (2014). Assessment of nutritional status of school going children in Andhra Pradesh. *Unique Journal of Medical and Dental Sciences* 02(01), 28-30.

Suvarna and Itagi S. K. (2009). Nutritional status and level of intelligence of school children, Karnataka. *Journal of Agricultural Science* 22(4), 874-876.

Tanner J. M., Whitehouse R. H. and Takaishi M. (1966) Standards from birth to maturity for height, weight, height velocity, and weight velocity: British children 1965. *Archives of Disease in Childhood* 41, 454-471.

Thakur R. and Gautam R. K. (2014). Prevalence of under-nutrition among School going boys (5-18 years) of a Central Indian city (Sagar). *Human Biology Review* 3(4), 364-383.

Thakur R. and Gautam R. K. (2015). Assessment of nutritional status among girls of 5-18 years of age of a Central Indian City (Sagar). *Human Biology Review* 4(4), 325-336.

Turck D. (2013). World Health Organization 2006 child growth standards and 2007 growth reference charts: A discussion paper by the Committee on Nutrition of the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition. *Journal of Pediatric Gastroenterology and Nutrition* 57(2), 258-264.

Vashist B. M., Joyti and Goel M. K. (2009). Nutritional status of adolescents in rural and urban Rohtak, Haryana. *Health & Population: Perspectives and Issues* 32(4), 190-197.

Waterlow J. C. (1997). Protein-energy malnutrition: the nature and extent of the problem. *Clinical Nutrition* 16, 3-9.

Wang Y. and Chen H. J. (2012). Use of Percentiles and Z -Scores in Anthropometry. In. V.R. Preedy, (ed.) *Hand Book of Anthropometry: Physical measures of Human form in health and disease* 29-48. Springer -Verlag New York

World Health Organization. (1978). A growth chart for international use in maternal and child health care: Guidelines for primary health care personnel. WHO. http://www.who.int/iris/handle/10665/37294 (accessed on 27 April, 2018)

World Health Organization. (1995). Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee, World Health Organization Technical Report Series. 854. WHO.

World Health Organization Multicentre Growth Reference Study Group. (2006a.) WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. MGRSG.

World Health Organization Multicentre Growth Reference Study Group. (2006b.) Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study. *Acta Paediatrica Supplementum*. 450, 56–65. MGRSG.

World Health Organization AnthroPlus for personal computers Manual: Software for assessing growth of the world's children and adolescents. (2009). Geneva: WHO.

Yadav A. K., Kotwal A., Vaidya R. and Yadav J. (2016). Anthropometric indices and its socio-demographic determinants among primary school children of an urban school in Pune, India. *International Journal of Medical Public Health* 6(4), 160-164.

Annexure

Methodological overview of literature on 'Nutritional Status of School-going Children in India' from 2000 to 2016

References	Location	Age-Group (Years)	Type of School	Methods Used	N	Prevalence
Bandikolla 2016	Kakani, Guntur District, Andhra Pradesh	12	Government School	ICMR WHO	100 boys	BMI for boys were 17.7± 9.7 kg. which is lower than the standard values.
Selvaraj et al. 2016	Semi urban Southern part of India	9-17	6 schools	WHO criteria based on Z-score	2100 (boys: 46.1% and girls: 53.9%)	Obesity: 6% Overweight:10.9% Thinness:13% Severe thinness: 5% Stunting: 19.8%
P. Sasikala 2016	Rompicherla Mandal, Andhra Pradesh	5-15	Government school	Not Available	613	grade-I malnutrition: 24.14% grade-II malnutrition: 16.48% grade-III malnutrition: 9.95%
Kumaravel et al. 2016	South Indian district	5-18	25 Government and 25 Private (includes primary, middle, high schools and higher secondary schools)	IAP International (IOTF) BMI Cut-Offs	18001 (55.1% boys) (55.1% from government schools and 44.9% from private schools)	Thinness: 12.2% Overweight: 9.5% Obese: 3%
Pal et al. 2016	20 educational districts of West Bengal	6-13	Primary and upper-primary school	IAP	24108	Overall under-nutrition: 22.8% Over weight and obesity: 3% Exclusive underweight: 5.5% Exclusive stunting among 6.3% and both were present in 11%
Shashank and Chethan 2016	Rural Ukkali, Bijapur, Karnataka	6-12	Not Available	NCHS ICMR	284 (62.6% boys and 37.3% girls)	Underweight: 34.15% (31.4% boys and 38.6% girls) Stunted: 25% (24.2% boys and 26.4% girls)

References	Location	Age-Group (Years)	Type of School	Methods Used	N	Prevalence
Kumar et al. 2016	Urban slum Bengaluru, Karnataka	5-14	Primary school	WHO 2007 reference growth charts	404 (56% boys and 44% girls)	Underweight among male and female children were almost the same (< 3rd percentile) whereas stunting also showed both children under same level of percentile
Yadav et al. 2016	Urban Pune, Maharashtra	5-11 (Std. I-V)	Primary school	WHO/NCHS	760 (59.3% boys and 40.7% female)	Stunted: 4.47% (severe- 0.4%) Wasting: 6.32% (severe- 0.3%) Underweight: 5% (severe – 0.1%)
Abraham et al. 2015	Coastal area Puducherry	5-17	Higher secondary school	WHO criteria	714 (51.4% boys and 48.6% girls)	Underweight (5-9 years): 30.7%, moderate-29.6% and severe- 1.1% Stunted: 10.4%, moderate- 10.2% and severe- 0.1% Thinness (low BMI-for-age): 30.7%, moderate- 26.9% and severe- 3.8%
Bhattacharya et al. 2015	Burdwan distict, West Bengal	10-19	Government schools	NCHS	424 (61.79% boys and 38.21% girls)	Underweight: 53.31% Stunted: 47.41% Boys were more malnourished than girls Early adolescents were more stunted than late adolescents
Thakur and Gautam. 2015	Sagar town of Sagar district, Madhya Pradesh	5-18	Government schools	NCHS	312 girls	Stunted: 5.4% Underweight: 5.7% Undernourished: 4.1%
Cynthia Subhaprada 2015	Urban slum Kurnool, Andhra Pradesh	6-10	Government primary school	IAP	101 (48 boys and 53 girls)	Grade-I malnutrition: 35.64% Grade-II malnutrition: 15.84% Grade-III malnutrition: 10.89%
Chandra-mohan et al. 2015	Udupi district, Karnataka	9-11 (Std.V students)	1 primary school	CDC BMI-for-age growth charts for girls and boys	76 (55% boys and 45% girls)	Underweight: 51% Overweight: 1%

References	Location	Age-Group (Years)	Type of School	Methods Used	N	Prevalence
Kamath et al. 2015	Bellary district, Karnataka	Std. III - VII	169 schools	WHO Multicenter Growth Reference Study growth charts	27544 (49.1% boys and 50.9% girls)	Undernourished: 16.1% 16.9% boys undernourished and 12.3% girls obese
Singh and Sekhon 2015	Sri Muktsar Sahib, Punjab	6-15	DAV Public School	NCHS (in collaborations with the National Center for Chronic Disease Prevention and health promotion 2000)	863 (57.3 boys and 42.6% girls)	Gross body measurements shows increasing trend with advancing age irrespective of the gender variations. In boys, from 6 to 15 years mean weight, height and BMI ranging between 20.9 to 53.9 kg, 116.9 to 164.8 cms. and 15.2 to 19.7 kg/m^2 respectively. In girls, from 6 to 15 years mean weight, height and BMI ranging between 19.1 to 49.1 kg, 115.8 to 157.7 cms. and 14.1 to 19.6 kg/m^2 respectively. Prevalence of malnutrition is more than the overweight and obesity in both girls and boys
Ashok et al. 2014	Mysore city	6-12	1 Government and 1 Private (primary school)	CDC	1566 (50.9% boys and 49% girls in government and 47.9% boys and 52% girls in private school)	Underweight: 24.5% Overweight: 8.4% Obesity: 4.1% Underweight was more in government than private school overweight was more in private than government schools
Sangwan et al. 2014	Fatehabad district, Haryana	6-12	Government primary school	IAP Waterlow classification	350 (155 boys and 195 girls)	Grade-I malnutrition: 44.47% Grade-II malnutrition: 28.28% Grade-III malnutrition: 2.0% Wasted: 61.43%; severely Wasted: 0.58% and boys affected more than girls Stunted: 36.86% and girls affected more than boys overall children 10 years and above mostly affected

References	Location	Age-Group (Years)	Type of School	Methods Used	N	Prevalence
Kumar et al. 2014	Rural Fatehabad district, Haryana	6-10	Primary school	IAP Waterlow classification	397 (193 boys and 204 girls)	Grade-I malnutrition: 38.29% Grade-II malnutrition: 20.90% Grade-II malnutrition: 4.79% Wasted: 63.48%; severe Wasting: 0.5% Mild stunted: 48.60%; Moderate stunting: 4.30% girls were affected more than boys 6 years and 9 years were at highest risk of wasting and stunting respectively
Thakur and Gautam 2014	Sagar town of Sagar district, Madhya Pradesh	5-18	10 schools	NCHS WHO	300 boys	Stunted: 6.3% Underweight: 4.3% Undernourished: 3%
Shivaprakash and Joseph 2014	Rural BG Nagara, Nagamangala Taluk, Mandya district, Karnataka	6-12	BGS Model Public School	ICMR NCHS	484 (52.5% boys and 47.5% girls)	Underweight: 30.3% (boys: 32.3% and girls: 28.3%) Stunting: 27.9% (boys: 29.1% and girls: 26.5%)
Malpani et al. 2014	Rural Raichur district, North Karnataka region, Karnataka	5-14	Not Available	WHO 2007 Reference Growth Charts	270	The level of malnutrition for underweight among male and female children was almost the same (<3rd percentile) whereas stunting also showed both children under same level of percentile.
Singh et al. 2014	Dhaura Tanda, Bareilly district, Uttar Pradesh	5-18	A hospital based study with school children as a subject	WHO	561 (50.80%) boys and 49.20% girls)	Underweight: 41% (44.56% boys and 37.32% girls) Stunted: 23.88% (26.32% boys and 21.38% girls) Thinned as per BMI: 36.18% (38.25% boys and 34.07% girls) Boys were more malnourished than girls.

References	Location	Age-Group (Years)	Type of School	Methods Used	N	Prevalence
Sridhar et al. 2014	Rural Andhra Pradesh	6-12	Government primary and high schools	Not Available	1050 (503 boys and 547 girls)	926 children were below average weight for age showing under nourishment, out of which 451 (42.95%) were boys and 475 (45.24%) were girls. (48.86%) children fall into normal range with average BMI
Hasan et al. 2013	Azad Nagar and surrounding areas, Bangalore, Karnataka	5-14	Government Urdu higher primary schools	NCHS	500 (59.8% boys and 40.2% girls)	Underweight: 58.2% (boys: 65.5% and girls: 47.2%)
Suba et al. 2013	Rural Kalapet, Puducherry	6-17	School	reference values of National Health and Statistics Report, CDC (according to National Health and Nutritional Survey 2003-06)	548 (261 boys and 285 girls)	BMI: lower for all age groups in comparison to the reference value Among both boys and girls the difference in the mean BMI was observed to increase as age advanced.
Dhanasekaran et al. 2013	Pulianthope zone of Chennai	6-10	Government primary school	NCHS CDC	320 (52% boys and 48% girls)	Underweight: 54.3% Overweight: 6.1% Underweight was high among girls than boys and underweight significantly increased with age
Deb and Dhara 2013	Rural Belonia district, Tripura	6-10	Primary school	ICMR WHO Gomez classification Waterlow classification	152	Underweight: 94.73% boys and 92.11% girls Stunting: 50.00% boys and 44.73% Chronic Energy Deficiency-III: 98.68 % boys and 100 % girls

References	Location	Age-Group (Years)	Type of School	Methods Used	N	Prevalence
Das et al. 2012	Rural Kharagpur, Paschim Medinipur district, West Bengal	6-12	5 Primary schools	new internationally accepted BMI cut-off values	500 (250 boys and 250 girls)	Thinness: 77.6 % boys and 76.4 % girls Girls are more undernourished than their male counterpart of the same age. Boys are more undernourished at age 7, 10 and 11 years than the girls of same age. Grade I thinness is found to be most prevalent among boys in all ages except age 11 and 12 years followed by grade II and III. Grade III thinness is found to be most prevalent among girls in all ages except age 7, 9 and 11 years followed by grade II and I.
Sati and Dahiya 2012	Rural Mangali and Kaimri villages of Hisar district, Haryana	7-9	Government primary school	NCHS ICMR Gomez Classification	200 (50% boys and 50% girls)	Stunted: 54.11 % Underweight: 55.5%
Nigudgi et al. 2012	Gulbarga city, Karnataka	10-13 and above	Higher primary schools	Not Available	935 (51.23% boys and 48.77% girls)	50.05% children were below average weight for age showing undernourishment
Fazili et al. 2012	Rural Hajin block, Kashmir	5-14	Primary and middle level educational facilities	WHO Z-score system	940	Overall under-nutrition: 19.2% Underweight: 11.1% Stunting: 9.25% Wasting: 12.3% Thinness: 29% In all the age groups more males were found to be underweight than females. In seven out of nine age groups the proportion of stunted children was higher among males. The same trend was observed for wasting also. For the indicator thinness the prevalence was higher in females in lower age group and vice versa.

References	Location	Age-Group (Years)	Type of School	Methods Used	N	Prevalence
Hasan et al. 2011	Azad Nagar and surrounding areas, Bangalore, Karnataka	5-14	Government Urdu higher primary schools	WHO	700	Malnutrition: 52% (boys: 53.85% and girls: 49.25%) Stunted: boys- 41.47% and Girls- 38.81%
Manna et al. 2011	Two districts of North Bengal, West Bengal	5-12	Not Available	ICMR Gomez classification Waterlow's classification	4457	Average height and weight of the children were lower than the national standard of ICME specifications. Weight-for-age: 80.01% boys and 77.86% girls with different degrees of malnutrition Height-for-age: boys with mild and moderately impaired nutritional status were higher than girls; more at higher ages than lower ages.
P. Navaneethan et al. (2011)	Pernambut block, Vellore district, Tamil Nadu	11-18	Government and Government aided schools	WHO	806	Underweight BMI: 83% Normal BMI: 16% Overweight and obese: 0.45%
Banerjee et al. 2011	Rural Northern Belt, Goa	10-19	Secondary Schools	Not Available	1015 adolescents (565 boys and 450 girls)	Underweight BMI: 37.8% boys and 27.5% girls. Overweight BMI: 2.8% boys and 4% girls More boys were underweight than girls and under-nutrition was uniform across all the years of schooling
Iyer et al. 2011	Both rural and urban Vadodara, Gujarat	Not Available	Not Available	The 5th percentile values of BMI of Must et al., Agrawal standards and CDC standards	376 (256 were from rural setup and 120 from urban)	Prevalence of under-nutrition was found in both urban and rural setup. The prevalence of underweight and stunting was high in both rural and urban adolescent children, with magnitude and severity being higher in rural children than urban. The overall prevalence of obesity ranged from 0.4-0.8 % in rural setup and 0.8-3.3 % in urban setup. Thus dual burden of malnutrition was seen in both the settings.

References	Location	Age-Group (Years)	Type of School	Methods Used	N	Prevalence
Dambhare et al. 2010	Peri-urban Wardha	10-19	High school	WHO NCHS	116 (80 boys and 36 girls)	Underweight: 51.7% Stunted: 34.5% Early adolescents age group were at highest risk
Chakraborty and Bose 2009	Nandigram, Purba Medinipur district, West Bengal	5-10	School	New international BMI bases classification cut-off points	596 (323 boys and 288 girls)	Thinness: 62.9% in boys and 61.6% in girls
Vashist et al. 2009	Rural and Urban Rohtak, Haryana	13-16	Government and Private	NCHS	500	Thinnesss: 24.5-31.5% among males and 14/6-15.8% among females in rural areas; 21.9-34.1% among male and 11.5-19.8% among females in urban areas Stunting: 6.5-15.2% among males and 7-14% among females in urban areas
Saluja et al. 2009	Urban Meerut	5-11	5 Government primary school	IAP Waterlow classification	800	Grade-I malnutrition: 35.5% Grade-II malnutrition: 11.4% Grade-III malnutrition: 2.6% Wasted: 44.6%; severely Wasted: 1.2% Stunted: 43.8%
Suvarna and Itagi 2009	Rural four villages from Dharwad district, Karnataka	7-10	Government Kannada medium school	NCHS Waterlow classification	102	Wasted: 35.29% (less than 8 years age group: 15.38%, 8-9 years age group: 47.27%, older age group: 28.57%) Stunted: 36.27% (less than 8 years age group: 50%, 8-9 years age group: 34.54%, older age group: 23.80%)
Ruchika et al. 2008	Allahabad district, Uttar Pradesh.	7-10	Not Available	NCHS standards	150	Wasted: 3% Stunted: 17.3% Underweight: 25%

References	Location	Age-Group (Years)	Type of School	Methods Used	N	Prevalence
Bose et al. 2007	Rural Onda, Bankura district, West Bengal	6-14	7 primary and secondary schools	NCHS WHO	454 (201 boys and 253 girls)	Underweight: 16.9% Stunted: 17.2% Thinness: 23.1% Underweight and thinness in boys was very high, thinness was very high in girls
Semwal et al. 2006	Rural Doiwala block, Dehradun district	6-14	6 government secondary schools	ICMR Waterlow classification	930 (377 boys and 553 girls)	Wasted: 52.6% Stunted: 26.3% 10-14 years old affected most.
Chandra et. al. 2006	Rural Dharwad and Haliyal taluks, Karnataka	4-14		WHO/ Government of India Road to Health card CDC 2000 Standard for BMI for the given age and sex	557 (260 boys and 297 girls)	Nutrition related disorders rate: 59.4%. Underweight /having lean BMI: 44.4% of children
Bharati et al. 2005	Both rural and urban Raichur taluk, Karnataka	5-13	Primary school	NCHS Waterlow classification	560 (50% rural and 50% urban)	Children from both locations were shorter than the NCHS standard. Similar trend was observed with regard to weight. higher percentage of rural children (32%) were grouped as normal and very low per cent of them (3%) were wasted as well as stunted, irrespective of age and sex.

About the Author

Nilanjan Bhor

Nilanjan Bhor is a public health researcher and has worked in various capacities in the field of public health for the last 9 years. His research interests are Social determinants of health, Epidemiology and broader issues of humanitarian crises. He is presently Project Coordinator with the Health, Development and Society team at the Azim Premji University. Prior to joining the Azim Premji University, he worked in the non-communicable disease programme at National Institute of Epidemiology Chennai and national Hepatitis B programme at Christian Medical College Vellore. He is an alumnus of Tata Institute of Social Sciences Mumbai, Christian Medical College Vellore and Manipal University, Manipal.

About Azim Premji University

Azim Premji University was established in Karnataka by the Azim Premji University Act 2010 as a not-for-profit University and is recognized by The University Grants Commission (UGC) under Section 22F. The University has a clearly stated social purpose. As an institution, it exists to make significant contributions through education towards the building of a just, equitable, humane and sustainable society. This is an explicit commitment to the idea that education contributes to social change. The beginnings of the University are in the learning and experience of a decade of work in school education by the Azim Premji Foundation. The University is a part of the Foundation and integral to its vision. The University currently offers Postgraduate Programmes in Education, Development and Public Policy and Governance, Undergraduate Programmes in Sciences, Social Sciences and Humanities, and a range of Continuing Education Programmes.

Azim Premji University
Survey No. 66, Burugunte Village,
Bikkanahalli Main Road, Sarjapura
Bengaluru – 562125

azimpremjiuniversity.edu.in

Facebook: /azimpremjiuniversity **Instagram:** @azimpremjiuniv **X:** @azimpremjiuniv