FOOD SECURITY AND STUNTING IN CHILDREN UNDER FIVE IN THE DEVELOPING WORLD

by

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ABSTRACT

Over the past decades, the concept of food security has evolved. The recent concept focuses on three pillars: food availability, food access and food use & utilization. This study used this broader definition of food security to identify the predictors of stunting among children in the developing world. Two stepwise regression models were run with national prevalence of stunting in children under 5 as the main outcome variable and 18 food security indicators as potential independent variables. The EM method was used to impute the missing values for the countries lacking data for the indicators. The models were also cross-validated. The models explained more than 67 % of the variance of stunting in the developing world. In both the models, the predictors of stunting were from all the three pillars of food security. This study highlights the importance of addressing all the pillars of food security to understand and tackle the stunting among children.

Keywords: Under-nutrition, stunting, food security, food availability, food access, food use and utilization

DEDICATION

To my parents

ACKNOWLEDGEMENTS

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1: INTRODUCTION

1.1 INTRODUCTION & BACKGROUND TO THE PUBLIC HEALTH PROBLEM

In order to achieve a healthy, productive and prosperous population, maintenance of food security is of vital significance (Nord, 2009). Limited or uncertain access to food is hazardous especially for the growing children because inadequate nutrition negatively affects their growth and development, health and future progress in life and even survival (UNICEF, 2009). Under-nutrition is the major consequence seen in children due to food insecurity (Gray et al., 2006). Under-nutrition is defined as “being underweight for one’s age, too short for one’s age (stunting), dangerously thin for one’s height (wasting) and deficient in vitamins and minerals (micronutrient deficiencies)” (UNICEF, 2009,p. 4). In 2008, an estimated 195 million children under the age of five were short for their age, 129 million children were underweight for their age and 26 million children were thin for their height (UNICEF, 2009). Africa and Asia account for the majority of this global burden of child under-nutrition (UNICEF, 2009).

Interventions implemented in the last two decades have led to a decline in the global prevalence of under-nutrition (UNICEF, 2009). However, most of this progress is a result of marked reduction in under-nutrition prevalence in China (UNICEF, 2009). Apart from that, progress has remained slow especially for Africa where the stunting and underweight prevalence have declined just three

and four percent respectively since 1990 (UNICEF, 2009). Despite this reduction in the prevalence, the number of undernourished children has actually increased due to an increase in the world population over the time (UNICEF, 2009).

The prevalence of under-nutrition among children under five is vital in assessing the progress regarding the first millennium development goal that aims at eradicating poverty and hunger. Failure to achieve a progress in the first MDG makes it difficult to succeed in other millennium development goals especially MDG 2, achieving primary universal education, and MDG 4, reducing child mortality (UNICEF, 2009).

1.2 PURPOSE

The concept of food security has evolved over time. The recent concept focuses on three main pillars: food availability, food access and food use and utilization (FAO, 2003). This concept of food security is an outcome of international food conferences and summits held by Food and Agricultural Organization since 1974 (FAO, 2003). These pillars of food security encompass a wide range of factors that can be helpful in understanding the prevalence of stunting globally. The child under-nutrition studies conducted in the past have not utilized the broader definition of the food security. Analyzing the relationship of stunting with food security pillars, will be useful in pointing out important areas that have been either neglected or overlooked in the past by major international organizations dealing with the issues of food security and child under nutrition, which include UNICEF, FAO, and WFP.

The present paper is the first attempt to determine the associations between stunting and the selected food security indicators from each of the three pillars of food security.

1.3 RESEARCH QUESTION

The research questions for this study are as follows:

1. Which food security indicators are predictors of national prevalence of stunting in children under five in the developing countries?
2. Which pillar of food security best represents the factors that predict stunting?

1.4 LITERATURE REVIEW

1.4.1 Child under-nutrition

Child under-nutrition is a major public health problem in low and middle-income countries of the world (UNICEF, 2008). Child under-nutrition results from lack of an adequate and nutritious diet, improper care and infections (UNICEF, 2008).

In the early 1970s, Waterloo proposed a classification for child under-nutrition that led to origin of the concept of stunting and wasting (Victoria, 1992). According to the Waterloo classification, stunting (inadequate height for age) resulted from chronic under-nutrition compared to wasting (inadequate weight for height) which was a consequence of acute food shortage (Shrimpton et al., 2001). The classification also revealed that children who are chronically undernourished could also develop acute under-nutrition (acute on chronic

nutrition), a condition in which both stunting and wasting would be present (Shrimpton et al., 2001).

A committee of the World Health Organization initially approved the Waterloo classification in 1977 (Victoria, 1992). However, in the next decade the WHO showed slight concern on the interpretation of Waterloo classification (Victoria, 1992). A WHO paper on the use of anthropometric indicators in 1986 stated that "terms such as acute under-nutrition for wasting, chronic under-nutrition for stunting and acute-on-chronic for the combination of wasting plus stunting, are not direct observations but deductions which may not always be correct" (Victoria, 1992, para. 1).

Currently, three anthropometric indicators used to assess child under-nutrition include stunting, wasting and being underweight (Reinhard, 2001). Unlike stunting and wasting, the measure of being “underweight” does not give any indication about the presence of either acute or chronic under-nutrition (Reinhard, 2001).

1.4.2 Stunting

Stunting is usually defined as, “the height for age below minus two standard deviations from the median height for age of the standard reference population” (UNICEF, 2009, p. 4).

Statistics indicate that stunting (195 million) is a bigger global burden than wasting (26 million) and underweight (129 million) (UNICEF, 2009). In 2008, 47 % of children in Africa and 36 % of children in Asia had a low height for their

respective age (UNICEF, 2009). These two continents account for more than 90 % of the children suffering from stunted growth worldwide (ibid). In addition, in nine developing countries (Afghanistan, Yemen, Guatemala, Timor-Leste, Burundi, Madagascar, Malawi, Ethiopia and Rwanda) more than 50 % of children, under the age of five, have stunted growth (UNICEF, 2009). Moreover, in countries with large populations, this high prevalence of stunting translates into a huge number of children with stunted growth. For instance, in India a stunting prevalence of 48 % equates to 61 million chronically undernourished children (UNICEF, 2009).

Research reveals that stunting of growth can occur during the second trimester of gestation due to an impaired nutrient supply to the fetus and can negatively affect fetal tissue growth (Branca, 2002). Postnatal stunting starts soon after birth and continues up to two years of life (Frongillo, 1999). Though the greatest degree of stunting occurs in first two years of life, research shows that the stunting can progress in school age years (Friedman et al., 2005).

The adverse consequences of stunting on a nation are severe and long lasting. Children who have stunted growth show delays in motor and cognitive development (Chilton, 2007). Stunted children are more prone to develop infectious diseases at an early age, which can further aggravate the growth faltering (UNICEF, 2009). Moreover, those stunted children who survive early life infectious diseases are at a higher risk of developing metabolic disorders in later life (Victoria, 2008) This sequence has been seen in countries where rates of

underweight children declined while prevalence of stunting remained high (UNICEF, 2009).

Risk of giving birth to low weight children is high in case of mothers who have suffered from chronic under-nutrition in their early life (UNICEF, 2009). Studies conducted in the developing countries have found an association between short maternal stature and offspring stunting (Ozaltin et. al., 2010). In addition, a study found that offspring stunting is also associated with paternal stature (Espo et al., 2002, Ozaltin et. al., 2010). Epigenetics (DNA methylation & histone modifications) explains this continuation of the stunted growth in the future generations (Ozaltin et. al., 2010).

Studies elsewhere have shown poor school performance in children and adolescents who suffered from stunting in early life (Mendez & Adair, 1999). In addition, some evidence exist that stunted children are more prone to develop anxiety, depression, low self-esteem and aggressive behaviour in their late adolescence (Walker et al., 2007). Poor school performance reduces the chances of acquiring appropriate earning capacity later in life (Victoria, 2008). Thus, a higher prevalence of stunted children per capita can result in a lower human capital per capita (Victoria et al., 2008). In sum, high rate of stunting can result in a poor country with reduced capacity and strength to grow and develop which further increases the chances of under-nutrition.

The adverse health effects of stunting are irreversible once they have developed (Shrimpton et al., 2001). This means that the interventions implemented once the growth faltering has occurred have, little significance.

Literature reveals that a number of indicators have been analyzed as predictors of stunting in wide range of settings. A majority of the studies have looked at the socioeconomic predictors of stunting in children aged less than five year. These studies have found higher stunting rates among children belonging to poor households (El Taguri et al., 2008, Ramli et al., 2009, Janevic et al., 2010). A population-based study conducted in South Africa found a negative association between prevalence of stunting among preschool children and employment status of the parents (Willey et al., 2009)

Research shows that factors like low education level of parents (Taguri et al., 2008), inadequate child feeding practices (Espo et al., 2002, Anderson et al., 2010), large household size (Sereebutra et al, 2006, Das et al.,2008), poor household sanitation and drinking water measures and the resulting infections (Bloss et al., 2004, Pongou et al., 2006, Medhin et al., 2010) and lack of proper access to health (Ramli et al., 2009) are associated with stunting in children aged less than five years. Inverse association between maternal literacy rates and child stunting has been seen in countries from different regions of the world such as Serbia (Janevic et al, 2010), Guatemala (Lee et al., 2010) South Africa (Willey et al., 2009) and Bangladesh (Das et al., 2008). Low diet diversity is another established risk factor of stunting seen in low and middle-income countries (Arimond and Ruel, 2004, Sawadogo et al., 2006, Rah et al., 2010).

1.4.3 Food security

Food security is a complex and flexible phenomenon. The definition has evolved considerably over the last three to four decades. Literature reveals almost 200 different definitions of food security (ODI, 1997). The right to adequate food was included into the Universal Declaration on Human Rights for the first time in 1948 at the forum of the United Nations (Reinhard, 2001). It is a fundamental requirement of every individual, community or a nation to be food secure in order to survive.

The concept of food security gained global attention after massive food shortages worldwide in the early 1970's (Reinhard, 2001). This led to the first World Food Conference in 1974 to understand the phenomenon of food security and its implications (Reinhard, 2001). Initial understandings of food security were mainly limited to ensuring food availability and stabilizing food prices at national and international levels (FAO, 2003). This is evident from the food security definition at the 1974 World Food Summit, which is:

"Availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (FAO, 2003, p. 27).

In the following few years, it was realized that the presence of sufficient amount of food was not enough to overcome food insecurity. Instead, it became understood that available food must be accessible to the people in need (FAO, 2003). As a result, FAO redefined food security in 1983 as:

“Ensuring that all people at all times have both physical and economic access to the basic food that they need”. (FAO, 2003, p.27)

With the passing time, the concept of food security went through further reconstruction. Focus broadened to availability and access to food, which is nutritious and is enough for “an active and healthy life” (FAO, 2003). In addition, the access to food was further broken down into physical, social and economic access. The recent definition of food security is as follows:

“Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO, 2003, p. 28).

Food security has now become a multidimensional phenomenon, which makes it difficult to measure. It now encompasses a wide range of food related and non-food related factors like sustainability in agricultural production, import-export balance, economic progress (WHO, 2009) climate change and natural disasters (FAO, 2005).

Despite the complexity of the food security phenomenon, it is now widely accepted that food security is built on three pillars: food availability, food access and food use and utilization (FAO, 2006). International organizations like WHO, USAID and FAO clearly mention food availability, food access and food utilization as the main dimensions of food security, on their respective websites and publications. The Food and Agricultural Organization has defined these three pillars as follows,

Food availability: “The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).” (FAO, 2006)

Food Access: “Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources). “(FAO, 2006)

Food Utilization: “Utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met.” (FAO, 2006)

Generally, food availability explains the supply side of food while the demand side determines food access (World Bank, 2008). However, these two dimensions are not completely separate because having enough money to buy adequate nutritious food is determined by not just one’s income, but also by the price of the food (Staatz, 2009). Thus, fluctuations in food prices at national and international levels influence both food availability and food access.

2: METHODS

2.1 CONCEPTUAL FRAMEWORK

The conceptual framework for child under-nutrition devised by UNICEF in 1990 considers food security, maternal health & childcare and health services and environment as the basic underlying factors affecting the stunting rates (Shrimpton et al., 2001). The maternal health & childcare is further dependant on economic, social and political factors (Shrimpton et al., 2001). Studies in the past have used this model to identify predictors of stunting.

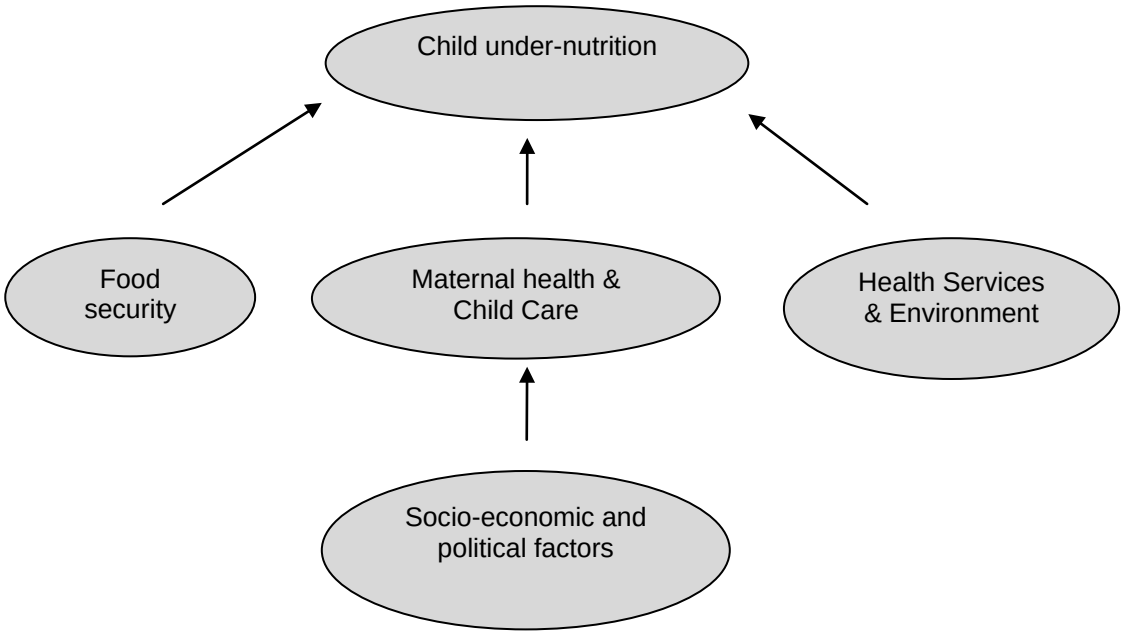

Figure 1 UNICEF Conceptual framework of stunting (UNICEF, 1990)

Provided the broadening of the concept of food security, the factors affecting the rates of under-nutrition and stunting seem to be strongly

interrelated. Indicators that determine the socioeconomic stability and health of households or nations, also influence their food security and all its dimensions whether directly or indirectly.

Food security pillars envelop a wide range of factors that can possibly influence the national prevalence of stunting. Studies in the past have not analyzed the linkage of stunting with the food security pillars and may have missed certain important factors. The complexity of the food security phenomenon might have limited this analysis. In addition, child-stunting studies in the past have focused mostly on household food security and hence were conducted in one setting or jurisdiction. Household food security is an essential component of food security but does not address the macro level implications of food security. For instance, factors like food price fluctuations, per capita food production and consumption that influence both food availability and access, cannot be addressed by just focusing on household food security. Apart from addressing pillars of food security, this study is an attempt to identify predictors of stunting using population level data from all the developing countries that have stunting prevalence of greater than or equal to 1 %.

Selection of Indicators- Stunting was chosen as main outcome variable because,

- Stunting is a bigger global burden compared to wasting and underweight (UNICEF, 2008)
- Stunting reflects chronic food insufficiency (Shrimpton et al., 2001)

- Unlike wasting and underweight, the adverse health effects of stunting are irreversible (UNICEF, 2008)

The complex nature of food security and its pillars makes it difficult to establish indicators that address all the dimensions. The definitions of food security pillars were utilized to identify different food security indicators. However, lack of a reliable data on certain aspects of food security issues limited the selection of food security indicators.

All matters, which relate to the physical presence of food within an area, determine the availability of food. These include production of food, food trade, domestic food reserves and food aids. Consumption of food per capita and diet diversification index depict the picture of availability of nutritious food in a country.

Enhancing agricultural development in developing countries has received a lot of attention at the World Food Summits to tackle under-nutrition and food insecurity (FAO, 2008). Indicators like the agricultural share of GDP and share of food imports in total food consumption shed light on the agricultural sustainability of the respective jurisdiction.

Indicators like vitamin A intake, iron availability and iodized salt consumption were selected because they are the most common micronutrient deficiencies among children in the developing world (UNICEF, 2009). In order to ensure food availability at all times, it is vital to keep the pace of domestic food production along with the population growth. The average annual rate of dietary

energy consumption explains the effect of population growth on food consumption per person in the respective area.

Over the years, food aids have remained an important strategy to increase the availability of food in least developed countries. In order to see the impact of food aids on stunting, share of food aid in total food consumption was selected under the rubric of food availability.

Food access is a broad term and includes all matters whether legal, political, social or economic which affect in having an adequate nutritious diet. Indicators selected in this study aim mostly at the economic aspects of food access. Indicators under the rubric of food access include inequality in dietary energy consumption and an average annual inflation rate for the respective countries.

Food utilization highlights all the activities and facilities which are not only required for intake of a nutritious food but also ensure the physiological well being of an individual. These include hygienic ways of food processing and preparation, healthy feeding practices especially for children, adequate knowledge of food nutrition and hygiene at the level of household, clean water, proper sanitation facilities and proper health care.

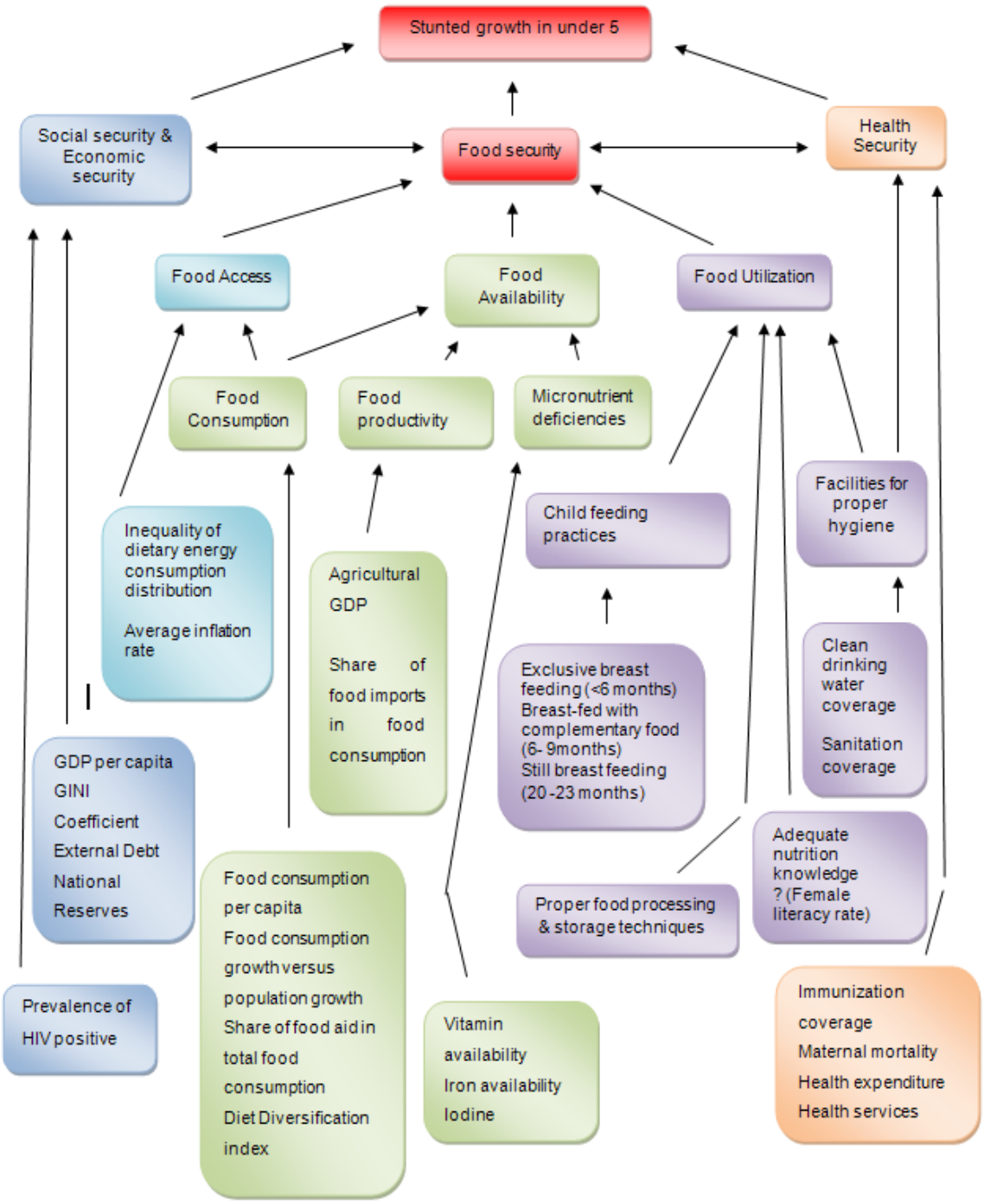

Figure 2 Conceptual framework - Stunting among under five and Food security

Data could not be found for any indicators that specify the food processing and storage in the particular population. Female literacy rate was used as surrogate for adequate knowledge of food nutrition and hygiene since the mothers are often primarily responsible for all the matters related to the hygiene and nutrition of children. Improper breast-feeding practices, unsafe water and inadequate sanitation can lead to illnesses like diarrhoea that can negatively influence the growth of the child (UNCEF, 2009). As a result, breast feeding indicators, improved sanitation coverage and improved drinking water coverage were added to the list of food use and utilization indicators.

Over the years, HIV prevalence has been related to under-nutrition. HIV infected regions are more vulnerable to food crises since HIV infected people are in greater need of an adequate nutritious diet (Baro, 2006) and often are too sick to contribute to food production . Studies conducted in the developing world reveal that children born with HIV infection are more vulnerable to stunting compared to HIV negative children (WHO, 2005). The growth faltering which results from being HIV positive has been seen well before the child has suffered from any opportunistic infections (WHO, 2005). High HIV morbidity and mortality in a region or a family not only diverts the public or households assets to the care of infected individuals but also reduces the overall productivity of the family or region and increases the dependency ratio within the family or region (Baro, 2006). A huge number of children in countries with high HIV prevalence are orphans due to the death of either one or both of the parents. Thus a higher

prevalence of HIV in a region raises the threat of economic insecurity and hence the food insecurity for the region or household (CHGA, 2008).

2.2 DATA SOURCES AND VARIABLE DEFINITIONS

The study design was cross-sectional and in some ways ecological, as national-level data on stunting and food security measures were examined. Consistent with the objective of the current study, the main outcome measure was prevalence of stunting in children under-five. All the independent indicators were continuous variables with the exception of vitamin A availability and share of food imports in total food consumption. In total, eighteen food security indicators were screened as predictors of stunting. The coefficient of variation in dietary energy consumption is estimated by combining the GINI coefficient, which measures the level of income inequality within a country, and the coefficient of variation in energy requirements (FAO, 2010). The coefficient of variation in dietary energy consumption measures an aggregate numerical measure of dietary energy consumption inequality, ranging from 0 (perfect equality) to 100 (perfect inequality) (FAO, 2010). Detailed definitions of the rest of the indicators can be found in Appendix A.

Data for dependent and independent variables were taken from the WHO, UNICEF, FAO and UNESCO. Data sources of the indicators are listed in Table 1.

Details about the statistical methods and standards used by the different data sources are available on their respective websites, which are listed in Appendix B.

Table 1 Data sources

INDICATOR	DATA SOURCE
Stunting among under 5 (%)	Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS) and other national household surveys, United Nations Children's Fund & WHO
Food consumption per capita (kcal/person/day), Diet Diversification index,	FAO Statistics Division
Iron availability (mg/person/day). Vitamin A availability (mcg/person/day),	FAO Statistics Division
% of households consuming iodized salt	Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS) and other national household surveys, United Nations Children's Fund & WHO
Inequality of dietary energy consumption distribution	FAO Statistics Division
% Share of agricultural GDP in the total GDP, % share of food imports in total food consumption	FAO Statistics Division
Food consumption growth versus population growth	FAO Statistics Division
% share of food aid in total food consumption	FAO Statistics Division
Annual inflation rate (1990-2007)	UNICEF
Female literacy rate 15+ (%)	UNESCO Institute of statistics
Infant and child feeding practices	Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS) and other national household surveys, United Nations Children's Fund
Improved drinking water coverage (%), Improved sanitation coverage (%)	Joint Monitoring Program for Water Supply and Sanitation – WHO, United Nations Children's Fund
HIV prevalence rate (15–49 years old)	Report on the Global AIDS Epidemic, 2008

2.3 STUDY POPULATION

UNICEF data reveal that there are 134 developing countries (Appendix C) in which stunting prevalence among children under five is ≥ 1 %. Out of 134 countries, indicator data were complete for 93 countries.

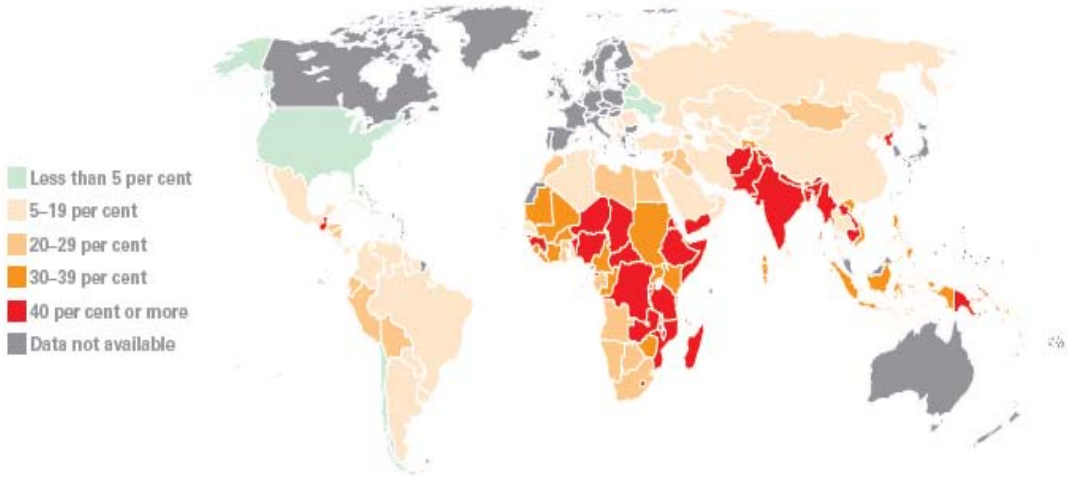

Figure 3 Percentage of stunted children under five years (UNICEF, 2008)

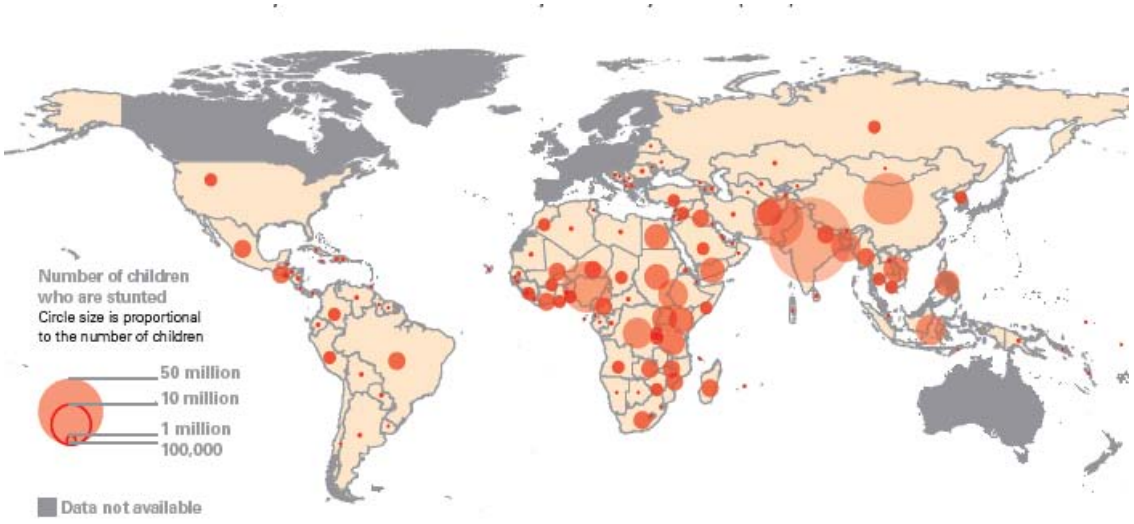

Figure 4 Number of stunted children under five years (UNICEF, 2008)

Table 2 presents a summary of the regional breakdown of the developing countries examined in the sample and Table 3 provides data on their level of development. Among the countries for which complete data were available for all the selected food security indicators, 40.9 % are in sub-Saharan Africa while 37.7 % of countries are in the category of least developed. Most of the counties for which data were not available for all the food security indicators are in Asia, Middle East and North Africa. In addition, 37.2 % of countries for which data were missing for some indicators are among the least developed countries.

Table 2 Regional breakdown of countries

Region	No. of countries with complete data	No. of countries with incomplete data
Sub-Saharan Africa	38	7
Asia	15	10
Middle East & North Africa	9	10
Latin America & the Caribbean	17	8
Central Eastern Europe	14	6
Total	93	41

Table 3 Breakdown of countries based on the level of development

Level of Development*	No. of countries with complete data	No. of countries with incomplete data
Least Developed (Developing) Countries	35	15
More Developed (Developing) Countries	58	26
Total	93	41

**: As classified by UNICEF (2009): Tracking progress on child and maternal nutrition: A survival and development priority.*

2.4 DATA ANALYSIS

Because of high positive skewness, average annual inflation rate, HIV prevalence, female literacy rate and share of food aid in total food consumption were transformed using the natural logarithm. Share of agricultural GDP in total GDP was transformed using the square root. (*The indictors which came out as predictors of stunting remained the same even without the transformation of above mentioned indicators. It is easy to interpret the results with untransformed indicators so, final results of regression analysis displayed in the next section are based on untransformed indicators).

Multiple linear regression analyses were conducted using the Statistical Package for Social Sciences (SPSS) version 17. Analysis of histograms, Q-Q plots and scatter plots, with and without inclusion of variables with missing values indicated that there was no violation of normality, linearity or homoscedasticity.

The food security data were complete for 93 countries. In order to overcome the missing data, EM (expectation-maximization) was used to estimate missing statistics and impute missing values. The EM method does not impute values for the categorical variables. As a result, the two categorical variables, vitamin A availability and share of food imports in total food consumption, were excluded from the independent variable list.

The EM method is a simple and robust method for imputing the missing values (B Do & Batzoglou, 2008). Two steps are repeated to find maximum likelihood estimates of the incomplete data: E step and M step (SPSS Inc., 2007). “The E- step calculates the conditional expectation of the missing data,

given the observed values and current estimates of the parameters. These expectations are then substitutes for the missing data. In the M-step, maximum likelihood estimates of the parameters are computed as though the missing data has been filled in" (SPSS Inc., 2007, p. 7).

One of the pre-requisite for the use of the EM method is the missing of data at random. Missing at random (MAR) means that the missing values are randomly distributed within the sample (SPSS Inc., 2007). Little's chi-square testing revealed that missing of data was completely at random. A regression analysis was done using the new data set.

Since the aim of study was to identify predictors of stunting, a stepwise regression method was used. Two models were run:

Model 1 - Stepwise regression without imputing the missing values

Model 2 - Stepwise regression after imputing the data for missing values by the EM method

Cross validation was also performed to assess the predictive power of both the models. For both models, the main sample was randomly divided in to 10 subsamples. One of the 10 subsamples was retained as the validation data for testing the model and the remaining subsamples were used as training set. A prediction equation was created using the training set. The equation was then used to calculate predicted stunting values for the member countries of validation sample. The process was repeated 10 times, with each of the ten subsamples

used exactly once as the validation data. The predicted stunting scores for all the member counties were then correlated with their observed stunting scores.

No analysis was done to analyze interactions between independent variables because it would not have been possible to look for interaction with the available data. Studies in future with primary data should look for interaction in these variables.

3: RESULTS

The prevalence of stunting ranged from 1% to 59% (M=27.28; SD=14.90) in the developing and least developed countries that were examined in the study. Descriptive statistics are listed in the Table 4.

Model 1 explained 76.1 % of the variation in childhood stunting in the developing world. The “percentage of children still breast feeding at 20 – 23 months”, “food consumption per capita”, “diet diversification index”, “percentage share of food imports in total food consumption” and “average annual inflation rate” came out as predictors of stunting under five among after the stepwise regression. The cross validation R^2 was 0.69 (Table 9).

The stepwise regression analysis done after imputing the missing values by the EM method lead to the inclusion of “co-efficient of variation in dietary energy consumption” and “improved sanitation coverage” in the predictor list. Increase in the sample size after imputing the missing values, resulted in addition of variables to the predictor list. “Food consumption per capita”, “diet diversification index” and “still breast-feeding (20- 23 months)” came out as predictors of stunting among under five in both models. Model 2 explained 72.9 % of the variation in childhood stunting in the developing world. The cross validation R^2 was 0.67 (Table 10).

Table 4 Descriptive statistics

	N	Min.	Max.	Mean	Median	Std. Deviation
Stunting %	134	1.00	59.00	27.28	27.00	14.90
Average annual inflation rate (%) 1990-2007	122	1.00	408.00	27.96	9.00	58.47
Estimated HIV prevalence	107	0.10	33.40	3.16	0.90	5.89
Female literacy rate	124	15.00	100.00	74.77	83.00	23.14
Improved drinking water	130	22.00	100.00	77.24	82.00	18.34
Improved sanitation coverage	130	9.00	100.00	59.97	59.00	25.94
% households consuming iodized salt	122	0.00	100.00	63.73	70.00	29.09
% exclusively breastfed(<6 months)	128	1.00	88.00	31.53	30.50	19.39
% breastfed with Complementary food (6-9months)	124	8.00	93.00	58.49	61.50	19.57
% still breast feeding (20-23 months)	120	2.00	95.00	38.36	35.00	21.26
Vitamin A availability	122	1.00	3.00	2.20	2.00	0.69
Iron (animal origin)availability	122	0.30	5.80	1.77	1.70	0.99
Food aid share in total food consumption (%)	115	0.00	26.70	2.34	0.80	4.12
% Share of agricultural GDP in the total GDP	130	0.20	64.30	18.89	14.90	14.47
food imports in total food consumption (%)	122	1.00	5.00	2.40	2.00	1.14
Diet diversification index	122	17.00	73.00	43.88	45.50	12.37
Coefficient of variation in dietary energy consumption	128	20.00	36.00	26.67	27.00	3.66
Food consumption per capita	122	1500.00	3470.00	2513.68	2460.00	432.89
Average annual rate of dietary energy consumption	121	-2.700	2.200	0.44	0.50	0.75
LOGHIV	107	-2.30	3.50	-0.15	-1.05	1.69
LOGFOODAID	115	-6.90	3.28	-1.72	-1.72	3.50
LOGINFLATION	122	0.00	6.01	2.46	2.19	1.183
LOGLITERACY	124	2.70	4.60	4.24	4.41	0.41
Square root – agricultural GDP	130	0.44	8.01	4.01	3.86	1.66

Table 5 Model Summary (Stepwise Regression – Before Imputing the Missing Values)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.69[a]	.47	.47	10.13
2	.78[b]	.60	.60	8.80
3	.81[c]	.66	.65	8.23
4	.84[d]	.71	.69	7.63
5	.86[e]	.74	.72	7.29
6	.87[f]	.76	.75	6.95
7	.87[g]	.76	.74	6.98

a. Predictors: (Constant), improved sanitation coverage

b. Predictors: (Constant), improved sanitation coverage, % still breast feeding (20-23 months)

c. Predictors: (Constant), improved sanitation coverage, % still breast feeding (20-23 months), Food consumption per capita

d. Predictors: (Constant), improved sanitation coverage, % still breast feeding (20-23 months), Food consumption per capita, Diet diversification index

e. Predictors: (Constant), improved sanitation coverage, % still breast feeding (20-23 months), Food consumption per capita, Diet diversification index, food imports in total food consumption

f. Predictors: (Constant), improved sanitation coverage, % still breast feeding (20-23 months), Food consumption per capita, Diet diversification index, food imports in total food consumption, Average annual inflation rate (%) 1990-2007

g. Predictors: (Constant), % still breast feeding (20-23 months), Food consumption per capita, Diet diversification index, food imports in total food consumption, Average annual inflation rate (%) 1990-2007

Table 6 Coefficients (Stepwise Regression before imputing missing values)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	51.52	2.83		18.18	.00		
	improved sanitation coverage	-.40	.04	-.69	-8.63	.00	1.00	1.00
2	(Constant)	33.19	4.27		7.76	.00		
	improved sanitation coverage	-.27	.04	-.47	-5.84	.00	.73	1.35
	% still breast feeding (20-23 months)	.27	.05	.42	5.24	.00	.73	1.35
3	(Constant)	55.08	7.35		7.48	.00		
	improved sanitation coverage	-.19	.05	-.33	-3.92	.00	.58	1.71
	% still breast feeding (20-23 months)	.22	.05	.34	4.34	.00	.67	1.48
	Food consumption per capita	-.01	.00	-.30	-3.54	.00	.58	1.70
4	(Constant)	68.99	7.75		8.89	.00		
	improved sanitation coverage	-.12	.05	-.21	-2.47	.01	.49	2.01
	% still breast feeding (20-23 months)	.16	.05	.24	3.17	.00	.60	1.66
	Food consumption per capita	-.01	.00	-.31	-3.99	.00	.58	1.70
	Diet diversification index	-.34	.09	-.29	-3.76	.00	.60	1.65
5	(Constant)	75.73	7.77		9.74	.00		
	improved sanitation coverage	-.08	.05	-.14	-1.66	.10	.45	2.18
	% still breast feeding (20-23 months)	.12	.05	.19	2.53	.01	.56	1.76
	Food consumption per capita	-.01	.00	-.35	-4.61	.00	.56	1.75
	Diet diversification index	-.32	.08	-.27	-3.64	.00	.60	1.66
	food imports in total food consumption	-2.50	.86	-.19	-2.90	.00	.73	1.36
6	(Constant)	82.87	7.77		10.65	.00		
	improved sanitation coverage	-.06	.04	-.11	-1.35	.18	.45	2.22
	% still breast feeding (20-23 months)	.09	.04	.14	1.93	.05	.54	1.85
	Food consumption per capita	-.01	.00	-.39	-5.32	.00	.54	1.82
	Diet diversification index	-.35	.08	-.30	-4.22	.00	.58	1.70
	food imports in total food consumption	-2.86	.83	-.22	-3.45	.00	.71	1.39
	Average annual inflation rate (%) 1990-2007	-.03	.01	-.17	-2.99	.00	.92	1.08
7	(Constant)	85.50	7.56		11.29	.00		
	% still breast feeding (20-23 months)	.09	.04	.14	1.96	.05	.54	1.85
	Food consumption per capita	-.01	.00	-.44	-6.75	.00	.71	1.40
	Diet diversification index	-.40	.08	-.33	-4.99	.00	.66	1.49
	food imports in total food consumption	-3.19	.79	-.24	-4.01	.00	.78	1.27
	Average annual inflation rate (%) 1990-2007	-.03	.01	-.18	-3.18	.00	.93	1.06

Table 7 Model summary (After imputing missing values by EM method)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.73[a]	.54	.54	10.10
2	.83[b]	.69	.68	8.35
3	.85[c]	.72	.72	7.88
4	.86[d]	.73	.73	7.72
5	.86[e]	.74	.73	7.60

a. Predictors: (Constant), Diet diversification index

b. Predictors: (Constant), Diet diversification index, Food consumption per capita

c. Predictors: (Constant), Diet diversification index, Food consumption per capita, coefficient of variation in dietary energy consumption

d. Predictors: (Constant), Diet diversification index, Food consumption per capita, coefficient of variation in dietary energy consumption., Average annual inflation rate (%) 1990-2007

e. Predictors: (Constant), Diet diversification index, Food consumption per capita, coefficient of variation-dietary energy consumption., Average annual inflation rate (%) 1990-2007, improved sanitation coverage

Table 8 Coefficients after imputing missing values by EM method

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	66.04	3.21		20.55	.00		
	Diet diversification index	-.88	.07	-.737	-12.53	.00	1.00	1.00
2	(Constant)	93.62	4.39		21.30	.00		
	Diet diversification index	-.60	.06	-.50	-8.78	.00	.72	1.37
	Food consumption per capita	-.01	.00	-.45	-7.87	.00	.72	1.37
3	(Constant)	57.24	9.72		5.88	.00		
	Diet diversification index	-.49	.07	-.41	-7.12	.00	.62	1.59
	Food consumption per capita	-.01	.00	-.38	-6.76	.00	.66	1.50
	Coefficient of variation in dietary energy consumption	.96	.23	.23	4.13	.00	.65	1.52
4	(Constant)	62.69	9.76		6.42	.00		
	Diet diversification index	-.51	.06	-.43	-7.54	.00	.61	1.62
	Food consumption per capita	-.01	.00	-.39	-7.07	.00	.65	1.51
	Coefficient of variation in dietary energy consumption	.86	.23	.21	3.74	.00	.63	1.56
	Average annual inflation rate (%) 1990-2007	-.03	.01	-.11	-2.54	.01	.96	1.04
5	(Constant)	62.37	9.61		6.48	.00		
	Diet diversification index	-.45	.07	-.37	-6.09	.00	.51	1.94
	Food consumption per capita	-.01	.00	-.32	-5.33	.00	.51	1.93
	Coefficient of variation in dietary energy consumption	.75	.23	.18	3.25	.00	.61	1.63
	Average annual inflation rate (%) 1990-2007	-.02	.01	-.10	-2.41	.01	.95	1.04
	improved sanitation coverage	-.09	.04	-.15	-2.24	.02	.39	2.50

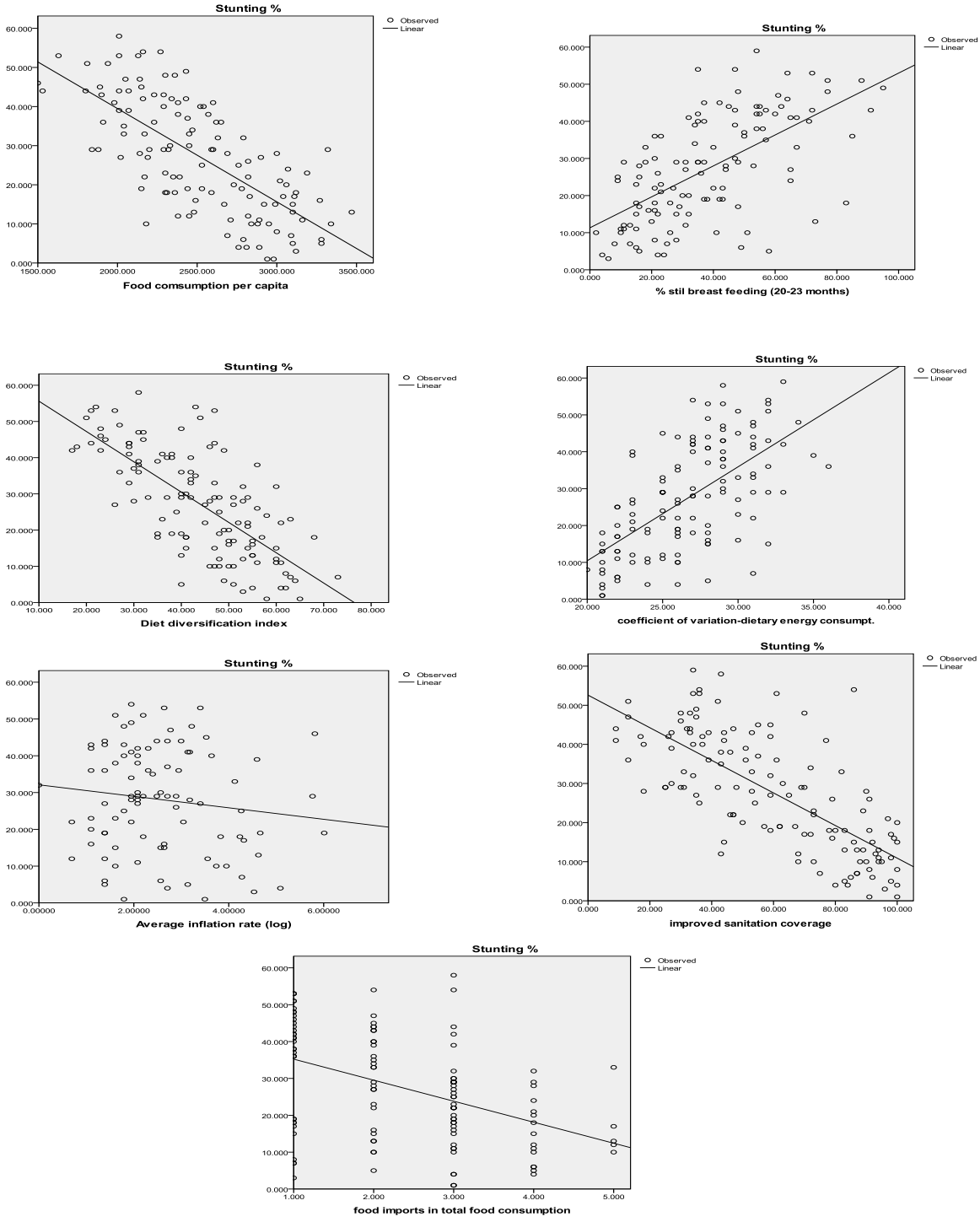

Figure 5 Graphical presentations of bi-variate association between stunting and the indicators that came out as predictors in the two models

In both models there was no indication of multi-collinearity, which is evident from tolerance values (all > 0.41) and VIF values (all < 2.4) (Table 6 & 8). In addition, the correlation matrix revealed that none of the predictors were correlated with each other at a significance level of 0.05.

Table 9 Cross validation results (Stepwise regression before imputing missing values

R^2 (from stepwise regression)	**Cross validation R^2**
0.76	0.69

Table 10 Cross validation results (Stepwise regression after imputing missing values by EM method)

R^2 (from stepwise regression)	**Cross validation R^2**
0.74	0.67

The table of predicted values of stunting for the respective countries, obtained after cross-validation, for both models are present in Appendix D.

Due to an unexpected negative association between average inflation rates and stunting, regression analysis was done for both models after excluding the average inflation rate from the dataset. There was a negligible decrease in R^2 in both models while the predictors of stunting remained same in both models.

Table 11 R-square before and after exclusion of inflation variable from independent variable list

Model	R^2 after exclusion of inflation variable	R^2 after exclusion of inflation variable
1	0.76	0.74
2	0.74	0.73

4: DISCUSSION

The finding that predictors of stunting come from each of the three pillars of food security demonstrates the need for a broad conceptualization of food security in order to predict stunting in children under five in developing countries. Given the significance of these indicators, the next section will discuss the implications of each of these food security indicators to under-nutrition and stunting.

4.1 FOOD CONSUMPTION

The first thing on which food consumption per person in a country is dependant is the food availability within the respective country, which has been the main pillar of food security since the term was first developed (Baro & Deubel, 2006). Sustainable increases in agricultural productivity are already among the goals of major international institutions such as the World Bank, United Nations Food for Agriculture Organization (FAO) and the International Fund for Agricultural Development, as well as an important strategy in bilateral development agencies and non- governmental organizations (Smith & Haddad, 2001). In most developing countries, agricultural production is the main avenue by which the amount of food available is increased, either by increased national food production for consumption or by providing foreign exchange for food imports (Smith & Haddad, 2001). Increasingly, fewer farmers practice subsistence agriculture, as most are orientated to the market for income

generation and for buying foodstuff (Johns & Sthapit, 2004). Furthermore, the agriculture sector employs 61% of workers in developing countries (World Bank 1999 as cited in Henson & Loader 2001), and small landholder farmers represent 90 percent of the rural poor (FAO , 2008). As such, food production and productivity need to address not only increasing food stocks, but also reducing rural poverty, increasing availability of land and generally improving the livelihood of farmers and their families (FAO, 2008).

4.2 DIET DIVERSIFICATION INDEX

In addition to food sufficiency, the nutritious and diversified nature of available food is crucial to decrease the prevalence of under-nutrition (Johns & Sthapit 2004). Accordingly, the Diet Diversification Index was also significant in both the regression models. The rise in mono-cropping for bio-fuel and other cash crops for export and the consequent diversion from food crops has affected food prices, and in some countries lowered the availability of basic food staples, and adversely affected nutrition worldwide (FAO, 2008). A study by Block et al (2004) found that a rise in rice prices in the late nineties in Indonesia forced households to buy less nutritious foods in order to afford the expensive rice. Some professionals argue that the recent increase in bio-fuel production and the resulting soaring of food prices will be fruitful for food security and agricultural production in the long run as it will result in increased income for farmers who own the land and increased chances of agricultural employment for those who are employed as labourers (FAO, 2008). Despite the income advantages for the

rural poor, the overall consequences of mono-cropping on lowering diet diversity make such policies of dubious value (Johns & Sthapit, 2004).

4.3 SHARE OF FOOD IMPORTS IN TOTAL FOOD CONSUMPTION

Globally, the industrial countries are the net exporters of food while the developing and least developed countries are the net importers (FAO, 2008). Despite this fact, it is safe to assume that due to high purchasing capacity of developed countries their food imports worth would be greater than that of developing and least developed countries. As a result, the share of food imports in total food consumption was negatively associated with stunting among under five in developing countries. This association emphasizes the importance of self-reliance rather than self-sufficiency.

4.4 STILL BREAST FEEDING (20 - 23 MONTHS)

Infant and child feeding guidelines issued by a number of international organizations encourage the breastfeeding of a child up to and beyond 2 years of life (WHO, 2005). Unexpectedly, the analysis of this study reveals that breastfeeding for 20 – 23 months was associated with increased prevalence of stunting. Studies mostly in non-industrialized societies have found similar results regarding the prolonged breast-feeding practice (Marquis, 1997). A recent community based cross-sectional survey conducted in Ethiopia by the Ethiopian Health and Nutrition Research Institute found that children who were breast fed for two or more years were at a higher risk of stunting (Teshome et al., 2009).

It is well known that after six months of age, a child needs complementary food to meet up the nutritional requirements. Therefore, in poor households, due to lack of enough additional food source, mothers are left with the option of feeding their children mostly with breast milk (Marquis, 1997). Research has also proven that reverse causality is the reason behind this positive relationship between prolonged breast feeding and stunting among children under five (Marquis, 1997).

4.5 AVERAGE ANNUAL INFLATION RATE

High inflation rates, especially for food products, are the major factor for rise in undernourishment and stunting in the last decade (FAO, 2008). Surprisingly, stunting prevalence was negatively associated with average inflation rates for the respective countries.

Upon stratifying the inflation data, the top three regions with higher average annual inflation rate (from 1990 – 2007) were Central Eastern Europe/ Commonwealth Independent States, Latin America and Caribbean and Sub-Saharan Africa. During the 1990's, countries in CES/ CIS experienced massive surge in their annual inflation rates mainly due to a dramatic increase in the prices of goods and services following their convergence to free market and liberalization (Paula & Koen, 1995, Fischer et al., 1996). Similarly, countries in Latin America experienced massive inflations due to their poor fiscal performance especially in the first half of 1990's (Bernanke, 2005). Due to the inflation surges in both these regions, their average annual inflation rates from 1990 to 2007 were higher compared to rest of the developing world. The higher

inflation rates for both the regions along with their low stunting prevalence resulted in a negative association between the stunting and the inflation variable for the whole sample.

4.6 IMPROVED SANITATION COVERAGE

It is important to highlight the importance of non-food inputs like health care access, water and sanitation on food security, which fall within food utilization or use (FAO, 2006). The environment in which food is produced and consumed is also important and affects nutrition. Related to child under-nutrition, the high prevalence of infectious diseases in developing countries is a major contributor, and these interact in a vicious circle (Müller & Krawinkel, 2005). Contaminated waterborne or food borne illnesses affect how the body absorbs nutrients, and even if food is available and accessible, under-nutrition continues to occur by virtue of the presence of these diseases such as chronic diarrhea (UNICEF, 2009). Therefore, using the model of food security to address stunting necessitates also dealing with sanitation and access to health care.

4.7 INEQUALITY IN DIETARY ENERGY CONSUMPTION

In developing countries, progress in consumption of nutritious food resulting from economic growth has remained limited to the economically advantaged groups of society (Hong, 2006). Consequently, a positive association was seen between the coefficient of variation in dietary energy intake and stunting among children under five. This association explains the importance of

tackling poverty and inequality in the society in order to reduce stunting among children under five, which cannot be achieved merely through economic growth.

4.8 FURTHER IMPLICATIONS

This study reveals significant associations between the selected food indicators and stunting in children under five in the developing world. Although one is unable to make claims of a causal relationship, this study highlights the importance of analyzing all three dimensions of food security to reduce stunting as predictors of stunting were from all the three.

Intervene all the three pillars within the context of chronic food insecurity - Over the years, UNICEF has been the major international organization dealing with the problem of child under-nutrition. A recent technical note by UNICEF acknowledges the importance of achieving long-term food and nutrition security in developing countries in order to reduce their child under nutrition rates (UNICEF, 2008). However, apart from educating the mothers about proper breast feeding practices, the focal point of all their other interventions has revolved around achieving short term or transitory food security. The major UNICEF interventions include distribution of fortified foods for children, provision of vitamin A supplements, and enhancing the consumption of iodine among households (UNICEF, 2009). Although, UNICEF has done significant effort to increase access to safe water and sanitation (2009), most of these interventions were implemented in areas hit by some environmental disaster.

Similarly, other international organizations (IMF, World Bank, WFP) have focused on financial and food aid to address food security (NAPC/FAO, 2004). These strategies were aimed only at transitory food security and their impact on chronic food security was minimal (NAPC/FAO, 2004). Strategies aimed at transitory food security were done in all the dimensions of food security i.e. availability, access and utilization (Staatz, 2009). However, when it comes to dealing with chronic food insecurity, which contributes to stunted growth in children under five, much of the focus has revolved around improving food availability by increasing agricultural production (Staatz, 2009). This strategy has been criticized for being an attempt by the West to grow food in the developing countries that can later be imported to fulfil their needs while at the same time keeping their focus on bio-fuel production (Staatz, 2009). The criticism seems unjust as the idea of boosting the agricultural sector in the developing world came to origin based on the statistics, which revealed that the majority of the low-income countries are net food importers. Even in 1999, more than 75% of the low-income countries were net food importers (FAO, 2003). However, with time it has been realized that food self-reliance is more important than food self-sufficiency. Future focus should be given to the policies that can make the developing countries more food self-reliant.

In sum, there is need for interventions at the global level that can address all the three dimensions within the context of chronic food security as stunting is an indicator of long term nutritional deprivation. The use of this food security framework will assist the decision makers of international organizations, such as

UNICEF and WFP, in sorting out areas that have been previously ignored to decrease stunting among under five and hence more targeted interventions could be devised. In addition, the use of the framework will be helpful in systematizing the interventions and will ease the process of monitoring the progress.

Need for international collaboration - One of the commitments made at the World Food Summit held in Rome in 1996 was to implement “polices that are conducive to fostering food security for all” (NAPC/FAO, 2004). However, one of the significant factors behind the rise in food prices after 2002 was the change in agricultural policies by major cereal producers, which include China, the European Union and the United States of America (FAO, 2008). The resulting reduction in food supply accompanied by the rise in oil prices and bio-fuel production led other countries to put a restriction on food export to overcome the food vulnerability within their countries (FAO, 2008). These developments reveal that trade based approaches to tackle food insecurity, important especially to achieve food access, are not given due priority. Furthermore, these developments emphasize the importance of international collaboration and coordination to develop strategies focused on improving all the three pillars of food security. World Food Summit, launched by Food and Agricultural Organization in 1996, can serve the purpose of establishing international collaboration. The Rome declaration by the World Food Summit in 1996 was an important landmark in establishing a global commitment on halving the number of hungry people by 2015 (FAO, 2008).

Enhance the global monitoring of food security indicators - Food security and its dimensions are complex and dynamic in nature. The Food and Agriculture Organization have done significant work to collect the data for food security indicators in different countries. However, research is still limited in countries that have the worst prevalence of under-nutrition and stunting. Data for the selected food security variables were incomplete for countries like Afghanistan and Yemen who have the highest prevalence of stunting among children under five globally. Data imputation methods can be used for imputing missing values for indicators in countries undergoing disturbance (civil wars, conflicts, lack of infrastructure) limiting the data collection. However, all the missing data imputation methods have statistical pre-requisites, which may be difficult to achieve. As a result, there is need for enhancing monitoring and surveillance systems in developing countries.

4.9 LIMITATIONS

Food security is a valuable term in addressing under-nutrition given that it can be used to characterize nations, communities, households and individuals, making it possible to use at different levels of analysis. However, this paper only looked at national-level data, therefore the importance of household-level and community food insecurity, which may be critical to addressing food security (Baro & Deubel, 2006), and in particular the pillar of food access, was not addressed.

Food stability is another important aspect of food security and can serve as a fourth pillar. Food stability is a part of food availability and food access and

is defined as “access to adequate food at all times” (FAO, 2006, p. 1). Factors that can destabilize food access and availability include economic crises (unemployment, inflation rates), natural disasters & climatic changes (earthquakes, floods, and drought) and political & social unrest and conflicts (wars, terrorism and corruption). Food stability factors such as natural disasters, climatic changes and political and social unrest were not included in the study due to lack of the data.

Gender inequality and women’s status are also important indicators for child nutrition (UNICEF 2009). However, they were not included in the study due to lack of a reliable population level data for the majority of the developing countries.

Food access and under-nutrition patterns can be different for the urban and rural populations within a country. This aspect was missing in the underlying study and should be addressed in future studies.

5: CONCLUSION

The broader definition of food security offers a nexus for understanding and addressing the multiplicity of factors related to under-nutrition and stunting in children under five. Furthermore, the term as it has been conceptualized in this study does not allow for simplistic or individualistic approaches to the problem of famine and under-nutrition, but rather underscores the importance of economic and socio-political solutions at the international level that addresses the root causes of under-nutrition and stunting.

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APPENDICES

APPENDIX A

Definitions of selected food security indicators

Food consumption per capita (kcal/person/day) – Amount of food consumption, in kcal per day, for each individual in the total population.

Diet diversification index - percentage share of non-starchy foods in total dietary energy consumption

Vitamin A availability (mcg/person/day) -"The dietary availability of vitamin A is calculated by converting the amount of food available for human consumption as estimated by the FAO Food Balance Sheets in equivalent of Vitamin A (micrograms of retinol activity equivalent - RAE). However the actual food consumption may be lower than the quantity shown as food availability depending on the magnitude of wastage and losses of food in the household". (FAO, 2010)

Categories of vitamin A availability

1 - Less than 300 mcg RAE/person/day

2 - 300 — 600 mcg RAE/person/day

3 - More than 600 mcg RAE/person/day

Iron availability (mg/person/day) - "The dietary availability of iron is calculated by converting the amount of food available for human consumption as estimated by the FAO Food Balance Sheets in equivalent of iron. However the actual food

consumption may be lower than the quantity shown as food availability depending on the magnitude of wastage and losses of food in the household" (FAO, 2010)

Food consumption growth versus population growth - The average annual rate of change of dietary energy consumption (kcal/person/day) — r PCDEC

The average annual rate of change of population — r POP

The average annual rate of change of total dietary energy consumption for total population (kcal/day) — r DEC

r PCDEC = r DEC - r POP (FAO, 2010)

Percentage share of food imports in total food consumption - Role of food imports in total food consumption. Data on imports are converted in kilocalories using conversion factors by commodities in order to calculate the share of imports in the total Dietary Energy Supply (FAO, 2010) Role of food imports in total food consumption (%) has been divided into five categories:

1) 0- 25
2) 25 – 50
3) 50 – 100
4) 100 - 150
5) 150 over

Percentage of households consuming iodized salt - Percentage of households consuming adequately iodized salt (UNICEF, 2009)

Percentage Share of agricultural GDP in the total GDP – The share of the country's GDP derived from agriculture (FAO, 2010)

Percentage share of food aid in total food consumption - Contribution of food aid shipments (cereals and non-cereal products) in total food consumption. Data on food aid in tonnes are converted in kilocalories using conversion factors by commodities in order to calculate the share of the food aid in the total Dietary Energy Supply (FAO, 2010)

Average annual inflation rates (1990- 2007) - The average annual inflation rate for a respective country from 1990 to 2007.

Inequality in dietary energy consumption- Two measures have been used to determine inequality of dietary energy consumption. 1) Coefficient of variation 2) GINI coefficient. The coefficient of variation of dietary energy consumption, is "defined as a composite of the coefficient of variation in income (CV_I) and the coefficient of variation of energy requirements (CV_R) as follows: $CV^2 = CV\_I^2 + CV\_R^2$. The CV_I is estimated using household Survey data. The CV_R is estimated using demographic and anthropometric data and recommendations on dietary energy requirements. The GINI coefficient of dietary energy consumption is derived from the coefficient of variation of dietary energy consumption defined above, under the assumption of log-normal distribution. (FAO, 2010)

Female literacy rate in 15+ - Percentage of literate female who are 15 and above (The United Nations Educational, Scientific and Cultural Organization (UNESCO) define a literate person as someone who can both read and write with understanding, a short, simple statement on his or her everyday life. A person who can only read but not write, or can write but not read is considered

illiterate. A person who can only write figures, his or her name or a memorized ritual phrase is also not considered literate.) (UN, 2009)

Exclusive breastfeeding (<6months) - Percentage of infants younger than 6 months old who are exclusively breastfed (UNICEF, 2009).

Breastfed with complementary food (6–9 months) - Percentage of infants 6–9 months old who are breastfed and receive complementary food (Data do not reflect the quality of complementary food used in developing countries.) (UNICEF, 2009)

Still breast feeding at 20-23months - Percentage of children 20 - 23 months old who are currently breastfeeding (UNICEF, 2009).

Improved Drinking Water Coverage (%) - Percentage of the population using improved drinking water source (UNICEF, 2009).

Improved – Piped into a dwelling, plot or yard, public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, rainwater collection (UNICEF, 2009)

Unimproved – unprotected dug well, unprotected spring cart with small tank/drum. Tanker truck, surface water (river dam, lake, pond, stream, canal, irrigation channels) (UNICEF, 2009)

Improved Sanitation Coverage (%) - percentage of the population using an improved sanitation facility (UNICEF, 2009).

Improved – Number of household members using improved sanitation facilities (facilities that ensure hygienic separation of human excreta from human contact), including flush or pour flush toilet/latrine to piped sewer system, septic tank or pit

latrine ;ventilated improved pit (VIP) latrine; pit latrine with slab; and composting toilet. (UNICEF, 2009)

Shared – Number of household members using sanitation facilities of an otherwise acceptable type shared between two or more households including public toilets (UNICEF, 2009)

Unimproved – Number of household members using sanitation facilities that do not ensure hygienic separation of human excreta from human contact, including pit latrines without a slab or platform, hanging latrines and bucket latrines (UNICEF, 2009)

Open defecation – Number of household members defecating in fields, forests, bushes, bodies of water or other open spaces (UNICEF, 2009.

APPENDIX B

FAO Statistics Division

http://www.fao.org/economic/ess/methodology/methodology-systems/publications-on-statistical-methods-and-standards/en/

UNICEF

http://www.unicef.org/statistics/index_24287.html

Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS) and other national household surveys

http://www.unicef.org/statistics/index_24302.html

http://www.childinfo.org/mics.html

Joint Monitoring Program for Water Supply and Sanitation – WHO, United Nations Children's Fund

http://www.wssinfo.org/definitions/methodology.html

UNESCO Institute of statistics

http://www.uis.unesco.org/template/pdf/EducGeneral/Indicator_Technical_guidelines_EN.pdf

APPENDIX C

i) List of countries for which data were available for all selected food security indicators

Asia – Bangladesh, Cambodia, China, India, Indonesia, Lao People's Democratic Republic, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Vanuatu, Vietnam

Central Eastern Europe/ Commonwealth Of Independent States – Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, Republic of Moldova, Tajikistan, Turkey, Turkmenistan, Uzbekistan, Ukraine

Latin America & The Caribbean – Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Venezuela, El Salvador

Middle East & North Africa – Algeria, Egypt, Iran (Islamic Republic of), Jordan, Lebanon, Morocco, Sudan, Syrian Arab Republic, Tunisia

Sub-Saharan Africa – Angola, Benin, Botswana, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire Democratic Republic of the Congo, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.

Below is the list of countries for which data were missing for one or more food security indicators.

ii) List of countries for which data were missing for some food security indicators

Asia- Afghanistan, Bhutan, Burundi, Maldives, Nauru, Papua New Guinea, Solomon Islands, Timor-Leste, Tuvalu, Singapore

Latin America & The Caribbean - Argentina, Belize, Guyana, Paraguay, Suriname, Trinidad & Tobago, Uruguay, Chile

Central Eastern Europe/ Commonwealth Of Independent States - Croatia, Montenegro, Romania, Russian Federation, Serbia, the Former Yugoslav Republic of Macedonia

Middle East & North Africa – Bahrain, Iraq, Kuwait, Libya, Occupied Palestinian territory, Oman, Qatar, Saudi Arabia, UAE, Yemen

Sub-Saharan Africa - Djibouti, Equatorial Guinea, Liberia, Mauritania, Mauritius, Niger, Somalia

APPENDIX D

Model 1- Table of observed and predicted values of stunting for respective countries

Country	Obs. Stunting (%)	Pred. stunting (%)	Country	Obs. Stunting (%)	Pred. Stunting (%)	Country	Obs. Stunting (%)	Pred. Stunting (%)
Albania	26	12.20	Eritrea	44	46.9	Myanmar	41	38.19
Algeria	15	11.30	Ethiopia	51	56.37	Namibia	29	30.35
Angola	29	27.96	Gabon	25	15.74	Nepal	49	41.08
Armenia	18	17.79	Gambia	28	27.46	Nicaragua	22	32.33
Azerbaijan	25	18.88	Georgia	13	11.3	Nigeria	41	32.07
Bangladesh	43	49.93	Ghana	28	33.14	Pakistan	42	31.97
Belarus	4	4.5	Guatemala	54	25.46	Panama	22	26.33
Benin	43	39.87	Guinea	40	38.7	Peru	30	26.99
Bolivia	22	30.47	Guinea-Bissau	47	40.16	Philippines	34	30.85
Bosnia	10	12.12	Haiti	29	33.68	Republic of Moldova	10	18.24
Botswana	29	24.72	Honduras	29	18.54	Rwanda	51	41.05
Brazil	7	9.77	India	48	39.40	Sao Tome and Principe	29	25.84
Burkina Faso	36	44.33	Indonesia	37	36.42	Senegal	19	37.5
Cambodia	42	38.64	Iran	5	19.78	Sierra Leone	36	41.56
Cameroon	36	33.41	Jamaica	4	7.69	South Africa	27	27.31
Cape Verde	12	21.38	Jordan	12	10.68	Sri Lanka	18	34.5
CAR	43	43.02	Kazakhstan	17	12.65	Sudan	40	28.79
Chad	41	44.83	Kenya	35	33.85	Swaziland	29	22.18
China	15	23.21	Kyrgyzstan	18	20.03	Syrian Arab Republic	28	13.12
Colombia	15	18.61	Lao People's Democratic Republic	48	39.89	Tajikistan	39	30.38
Comoros	44	39.78	Lebanon	11	3.29	Thailand	16	27.98
Congo	30	27.83	Lesotho	42	37.33	Togo	27	45.94
Costa Rica	6	10.31	Madagascar	53	47.68	Tunisia	6	9.6
Côte d'Ivoire	40	29.79	Malawi	53	43.21	Turkey	10	9.91
Cuba	5	4.63	Mali	38	37.77	Turkmenistan	19	20.5
Democratic Republic of the Congo	46	50.37	Mexico	16	6.21	Uganda	38	28.6
Dominican Republic	18	15.82	Mongolia	27	24.50	United Republic of Tanzania	44	50.4
Ecuador	23	22.39	Morocco	23	19.35	Uzbekistan	19	29.6
Egypt	29	18.01	Mozambique	44	50.88	Vanuatu	20	20.13
Venezuela	12	16.9	Ukraine	3	13.3	Zimbabwe	33	32.38
Viet Nam	36	34.43	El Salvador	19	23.37	Zambia	45	47.7

Model 2- Table of observed and predicted values of stunting for respective countries

Country	Obs. Stunting (%)	Pred. stunting (%)	Country	Obs. Stunting (%)	Pred. Stunting (%)	Country	Obs. Stunting (%)	Pred. Stunting (%)
Afghanistan	59	47.49	Cuba	5	5.85	Lebanon	11	7.5
Albania	26	11.75	DPR Korea	45	31.07	Lesotho	42	38.22
Algeria	15	18.21	DPR Congo	46	48.84	Liberia	39	49.7
Angola	29	43	Djibouti	33	27.04	Libya	21	10.9
Argentina	8	5.62	Dominican Republic	18	16.19	Madagascar	53	44.60
Armenia	18	23.21	Ecuador	23	16.45	Malawi	53	42.82
Azerbaijan	25	25.13	Egypt	29	23.4	Maldives	32	15.33
Bahrain	10	12.62	Equatorial Guinea	43	32.86	Mali	38	36.81
Bangladesh	43	46.49	Eritrea	44	49.02	Mauritania	32	25.77
Belarus	4	10.49	Ethiopia	51	54.88	Mauritius	10	14.85
Belize	22	15.81	Gabon	25	20.36	Mexico	16	13.4
Benin	43	39.69	Gambia	28	33.67	Mongolia	27	28.32
Bhutan	48	34.21	Georgia	13	20.65	Montenegro	7	12
Bolivia	22	28.12	Ghana	28	35.1	Morocco	23	24
Bosnia	10	14.9	Guatemala	54	35.57	Mozambique	44	47.14
Botswana	29	31.03	Guinea	40	30.36	Myanmar	41	33.37
Brazil	7	17.33	Guinea-Bissau	47	40.67	Namibia	29	33.97
Burkina Faso	36	41.77	Guyana	17	18.69	Nauru	24	32
Burundi	53	40.01	Haiti	29	44.43	Nepal	49	38.33
Cambodia	42	45.42	Honduras	29	24.25	Nicaragua	22	33
Cameroon	36	32.37	India	48	38.43	Niger	47	44.64
Cape Verde	12	28	Indonesia	37	33.8	Nigeria	41	32.49
C.A. R.	43	29.08	Iran	5	19.8	O. P. T.	10	29
Chad	41	45.2	Iraq	26	20.89	Oman	13	28.6
China	15	22	Jamaica	4	10.4	Pakistan	42	34.86
Colombia	15	16.27	Jordan	12	15.25	Panama	22	28.12
Comoros	44	34.81	Kazakhstan	17	8.57	Papua New Guinea	43	41.47
Congo	30	31.5	Kenya	35	34.89	Paraguay	18	24
Costa Rica	6	10.5	Kuwait	24	8.03	Peru	30	29.2
Côte d'Ivoire	40	31.77	Kyrgyzstan	18	23.18	Philippines	34	33.7
Croatia	1	3.8	Lao People's D. Republic	48	43.79	Qatar	8	10.39

Model 2- Table of observed and predicted values of stunting for respective countries

Country	Obs. Stunting (%)	Pred. stunting (%)	Country	Obs. Stunting (%)	Pred. Stunting (%)
Republic of Moldova	10	19.47	Trinidad and Tobago	4	14
Romania	13	3	Tunisia	6	9.32
Russian Federation	13	6	Turkey	10	10.46
Rwanda	51	42.73	Turkmenistan	19	19.86
Sao Tome and Principe	29	23.51	Tuvalu	10	18.38
Saudi Arabia	20	13.5	Uganda	38	27.65
Senegal	19	37	United Arab Emirates	17	8.33
Serbia	7	6.83	United Republic of Tanzania	44	43.02
Sierra Leone	36	48	Uruguay	15	10.49
Solomon Islands	33	39	Uzbekistan	19	27
Somalia	42	46.5	Vanuatu	20	25.85
South Africa	27	18.86	Venezuela	12	16.27
Sri Lanka	18	32	Viet Nam	36	29.13
Sudan	40	27	Yemen	58	36
Suriname	11	10.9	Zambia	45	37.99
Swaziland	29	22	Zimbabwe	33	29.96
Syrian Arab Republic	28	14	El Salvador	19	25.99
Tajikistan	39	28.7	Ukraine	3	8.5
Thailand	16	25	Chile	1	14
The former Yugoslav Republic of Macedonia	11	6.22			
Timor-Leste	54	41			
Togo	27	46			