Usual Nutrient and Food Intake of Filipino Stunted Children: Does It Matter?

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Abstract   The study focuses on the nutrient and food intakes of stunted children aged 3-5 y/o, 6-9 y/o, and 10-12 y/o. and determine the association between dietary factors and the prevalence of stunting. Data from the 2013 National Nutrition Survey in the Philippines were used. Stunting was defined as height-for-age < -2 SD of the reference population. Dietary factors were estimated based on the 24-h food recall. Results showed that stunted children had higher nutrients deficiencies. They had lower consumption of cereals, tubers, and roots, meat, poultry, and fish, and dairy. Compared to the lowest counterparts (Q1), preschoolers with higher intake of calcium (Q4) (OR=0.53, 95% CI: 0.38, 0.76) were less likely to become stunted, young school-aged with higher intakes of crude protein (Q4) (OR=0.59, 95% CI: 0.41, 0.84), iron (Q4) (OR=0.67, 95% CI: 0.46, 0.97) and lower intake of magnesium (Q4) (OR=1.42, 95% CI: 1.02, 1.98) have lower odds to become stunted, and older school-aged with higher intake of protein and thiamin (Q4) were associated with 40% and 34% reduced odds of being stunted (OR=0.60, 95% CI: 0.42, 0.87) (OR=0.66, 95% CI: 0.45, 0.98). Higher calcium and protein intake significantly influenced the reduction of the risk of being stunted among children.

Keywords: stunting, usual nutrient intake, food intake, DDS, prevalence of inadequacy

1. Introduction

The most direct causes of stunted growth were nutritional deficiencies from an early age, frequent occurrence of infectious diseases, and lack of psychosocial stimulation. Stunted children have slowed growth, elevated mortality, and diminished cognitive development, continued stunted as teenagers, and decreased earning ability as adults. The prevalence of stunting was declining gradually across the world from 32.6% in 2000 to 22.2% in 2017. However, there are still 150.8 million children that are stunted. Inadequate nutrition that is eating foods that lack growth-promoting nutrients is one of the direct causes of stunted growth [1,2,3]. In lower-middle-income countries (LMIC) with a daily average income of $2.7-$10.7 per person a day the prevalence of stunting is very prevalent (37.8 million) [4]. Despite the fact that there has been a great worldwide decrease in the prevalence of stunting, there is a perceived requirement for more data. Considerable experience has been accumulated, but more is needed, as are increased resource allocation and resources, and the quality of foods consumed.

In the Philippines, the prevalence of stunting under 5 years old children was 30.3%, school children aged 6-10 years old were 24.5%, and adolescents aged 11-19 years old were 26.3% [5]. Apart from this, more Filipino children are suffering from poor diets. Preschoolers aged 3-5 years old were inadequate of iron (90%), calcium (84%), vitamin C (60%), folate (72%), zinc (47%), thiamin (43%), riboflavin (43%), and vitamin A (43%) [6]. School children aged 6-12 years had a high prevalence of inadequate intake of calcium (93%), iron (87%), vitamin C (81%), folate (70%), riboflavin (67%), and vitamin A (63%) [7]. Almost half (46%) of Filipino households were food secure while 12.8% were severely food insecure [8]. Although several studies have been released on the dietary intake of Filipino children, no study has been published on characterizing the food sources and nutrient intake of stunted children which may contribute to the understanding of the still high prevalence of stunting in the country.

This study aims to evaluate the association of usual nutrient and food intake of stunted children aged 3 to 12 years old and the risk of stunting.

2. Methodology

2.1. Study Population

Data used for the analyses were derived from the 2013 National Nutrition Survey (NNS), a cross-sectional population-based survey that characterizes the health and nutritional status of the Filipino population. The dietary

survey used a stratified multi-stage sampling design including a total of 8,592 households. The first stage of the sampling involved the selection of the Primary Sampling Unit (PSU), which consisted of one (1) barangay or a contiguous barangays with at least 500 households. At the second stage, the Enumeration Area (EA) was selected, which consisted of contiguous areas in a barangay with 150-200 households. The last stage involved the selection of the households in the sampled EA that served as the ultimate sampling unit. Samples were taken separately from the regions by urban and rural strata. The individual dietary intake data from 8,881 selected group preschool children aged 3-5 years (n = 2,427), young school children aged 6-9 years old (n =3,529), and older school children aged 10-12 years old (n= 2,925) from the households were used in the current study. All surveyed households provided informed consent before participation. Ethical consent for the study was obtained from the Philippines Food and Nutrition Research Institute. To maximize the data, we compared the nutrient and food intakes of stunted children to those who were non-stunted regardless if they were healthy or not.

2.2. Data Collection

To estimate the day-to-day variance component in energy and nutrient intake required for the usual nutrient intake analysis, two (2) non-consecutive 24-h dietary recalls were collected. The first 24-h dietary recall was collected for all children and a second 24-h dietary recall was repeated in 50% of randomly selected households on a non-consecutive day (once on a weekday and once on weekend). Trained registered dietitians conducted the face-to-face interview of dietary recalls with the child or the parents/caregiver of each child during household visits using a structured questionnaire. All the foods and beverages that the child consumed including the detailed description of the foods eaten, the cooking method and brand names (e.g. for milk consumed or other processed snack foods) on the previous day are recorded with the estimated amount measured using common household measurements, such as cups, tablespoons, by size, or the number of pieces. Full details of the method of the dietary recall were accessible somewhere else [9]. All food items amount was converted into grams using a portion to weight list or through actual weighing of the food samples. Dietary supplements were not incorporated in the dietary survey.

To compute the energy and nutrient values, the cooked weight was converted to raw weight using the Individual Dietary Evaluation Software (IDES). The IDES contains a library of food composition values in their raw form. The Filipino Food Composition Table (FCT) was updated with 325 new food items found in the food consumption survey (2013 NNS) as well as the inclusion of new nutrients of all food items in the FCT. With this effort, the new Philippine FCT contains 27 nutrients with a total of 1359 food items. The compilation of the new FCT was discussed in the previous paper [10]. We only selected 15 nutrients that have a great impact on the growth and development of the children in the study. Total energy (kcal), crude protein (g), total carbohydrates (g), thiamine (mg), riboflavin (mg), niacin (mg), vitamin B6 (mg), vitamin B12 (mg), folate DFE (µg), calcium (mg), zinc (mg), phosphorus (mg), vitamin C (mg), iron (mg), and magnesium (mg) intake were included in the analysis.

Standing height (cm) was obtained for subjects of two years old and above using the Microtoise (SECA 206, Hamburg, Germany)—an L-shaped device (head-bar) to which a spring-loaded coiled tape measure was attached. Weight (kg) was measured using a mechanical Detecto® platform beam balance scales. At least two measurements were obtained, and averages were computed and recorded to the nearest 0.1 cm. A third measurement was only taken if the difference between the first two measurements was greater than 0.5 cm for height and 0.3 for weight [11]. The World Health Organization Child Growth Standards (WHO-CGS) was used to assess the nutritional status of children 0 to 5.0 years old (0-60 months), based on weight and height measurements [12] and WHO Growth Reference 2007 for the nutritional status of children 5.08 to 19.0 years old or 61-228 months [13]. The wealth status of families was classified by wealth quintiles, a composite measure of a household's ownership of selected assets including televisions, bicycles, materials used for housing construction, and types of water access and sanitation facilities. Scores were generated for each household asset and were then used to define wealth quintiles as poorest, poor, middle, rich, and richest. The in-depth methods of measurements and categorization were presented elsewhere [14].

2.3. Data Process

Food codes were reviewed to avoid misclassification and also the food amount to not under- or overestimate the values of nutrients. Two (2) steps were followed for cleaning the data. First, the ratio of daily energy intake to the estimated energy requirement EER was calculated for each person per day, then transformed to the logarithmic scale to remove outliers below -3 standard deviations (SD) and above +3 SD for each age group. Implausible micronutrient intakes, excessive intakes were defined as those that exceeded 1.5 times the 99th percentile of the observed intake distribution of the nutrient in the corresponding sex and age group. Intakes above the upper limit were substituted by a random value generated from a uniform distribution in the intervals with the lower bound equal to the 95th percentile of the observed intake and an upper bound equal to 1.5 times the 99th percentile [15]. The EER was calculated for each individual by using the equations for maintenance of body weight from the Institute of Medicine (IOM) based on age, gender, weight, height, and physical activity information [16]. We assumed a sedentary physical activity level for all preschoolers, and low activity for all young and older school children since the physical activity level of children was not included in the survey. Forty children aged 3-5 years were excluded in the study since they don't have height-for-age Z-score calculated. Another 27 children were excluded after detecting the outliers that may affect our estimates. A total of 8,814 children were included in the analysis.

Dietary Diversity Score (DDS) was calculated for each child using 10 food groups ((1) cereals, roots and tubers,

(2) meat, poultry, and fish, (3) other vegetables, (4) eggs, (5) other fruits, (6) dairy, (7) vitamin A rich fruit and vegetables, (8) legumes, pulses and nuts, (9) oils and fats, and (10) other) based on the basic guidelines for validating DDS in non-breastfeeding children [17]. The food group "other," consisting of sugar, condiments, and spices, etc., was excluded in the analysis since this group does not contribute substantial nutrients. DDS was calculated by applying a 10-g minimum intake for all food groups. Total DDS was calculated by summing the number of each food groups consumed by the child in the 24-h period only. Individual DDS of less than four (<4) denotes inadequate intake (Low DDS) while ≥4 considered adequate (High DDS) [18].

2.4. Statistical Analysis

PC Software for Intake Distribution Estimation version 1.02 (PC-SIDE) implements the Iowa State University (ISU) method to estimate the distributions of usual intake of nutrient intake. This program estimates distributions of usual nutrient intake by removing the effect of day-to-day (intra-person) variability in intake from daily intakes. The Estimated Average Requirements (EARs) defined by the Philippine Dietary Reference Intakes (PDRI) 2015 will serve as the cut-offs to calculate the prevalence of inadequacy of each nutrient. Prevalence of inadequacy of carbohydrates and crude protein as percentage of total energy was evaluated using Acceptable Macronutrient Distribution Ranges (AMDR). The proportion of inadequate intakes was classified as less than the AMDR lower range [19,20].

Stata 15 (Stata Statistical Software, release 15, Stata Copr. 2017) was used for all data processes and statistical tests. The percentage of children consuming each food group was expressed by the percentage of individuals who consumed specific foods or food groups at least once in the 24-h dietary recall, regardless of the amount consumed [21]. Median (25th, 75th percentile) intake per capita of each food group was also calculated for comparison of the consumption between non-stunted and stunted children. T-tests were performed to examine the mean differences of energy and nutrient intakes between non-stunted and stunted groups based on the means and standard errors from the PC-SIDE. Test for the difference of two population proportions was used to test the difference of the prevalence of inadequacy of each nutrient between non-stunted and stunted groups. A Chi-square test was performed to test the association between dietary diversity level and prevalence of stunting. Wilcoxon rank-sum test is a nonparametric test that is used to assess whether the distribution of the consumption of each food group intake differs between non-stunted and stunted groups. Pearson's Correlation was done to test the association between height-for-age (HAZ) and Dietary Diversity Score (DDS).

For the association study, we estimated the best linear unbiased predictor (BLUP) of usual energy and nutrient intake, calculated on the PC-SIDE software. We generated quartiles (Q1, Q2, Q3, & Q4) to categorize each estimated usual energy, nutrient, and food group intakes into four groups using xtile command. Quartile 1 represents the lowest intake while Quartile 4 represents the highest intake. For the prevalence of stunting, we used

multivariate logistic regression to estimate the adjusted odds ratio (OR) comparing Q4, Q3, and Q2 to the lowest quartile (Q1) adjusted for covariate sex, urbanity, and wealth quintile [22]. All 15 nutrients and 9 food groups including dietary diversity levels were included in the logistic regression model. Backward selection with 0.10 level of significance for removal and 0.05 significance level for the addition were applied in the model. Factor variables were inserted in the model from greatest to least important on the child's growth. A p-value < 0.05 was considered statistically significant and all tests were two-sided. All analyses were accounted for the complex survey design and sampling weights to reflect nationally representative results.

3. Results

Table 1 shows the descriptive characteristics of the participants. Boys and girls were equally distributed for all groups. More than half of these children were from rural residences (59%). Half of the participants were classified as poor while the other half was divided into middle and rich groups. Overall, about three out of ten of these children were stunted. For preschoolers, the mean body weight (standard deviation), height (standard deviation), and BMI (standards deviation) were 15 kg (3), 100 cm (7.6), and 15 kg/m2 (1.8), respectively; 22 kg (5.2), 119 cm (8.5), and 15 kg/m2 (2.2) for young school children; and 31 kg (8.4), 137 cm (9.4) and 16 kg/m2 (2.8) for older school children.

Table 1. Characteristics of the Participants (NNS 2013, Philippines)

	Age Group		
	3-5 years old	6-9 years old	10-12 years old
Sample, n	2427	3594	2971
Sex[1]			
Boys	1196 (49)	1841 (51)	1546 (52)
Girls	1231 (51)	1753 (49)	1425 (48)
Urbanity[1]			
Rural	1385 (57)	2060 (57)	1764 (59)
Urbanity	1042 (43)	1534 (43)	1207 (41)
Wealth Quintile[1]			
Poor	1229 (52)	1812 (52)	1581 (54)
Middle	451 (19)	649 (19)	519 (18)
Rich	681 (29)	1030 (19)	798 (27)
Prevalence of Stunting[1]			
Non-stunted	1647 (69)	2511 (71)	1988 (68)
Stunted	740 (31)	1018 (29)	2925 (32)
Anthropometrics[2]			
Body Weight (kg)	15 ± 3	21.6 ± 5.2	31.3 ± 8.4
Height (cm)	99.8 ± 7.6	119.2 ± 8.5	137.2 ± 9.4
BMI (kg/m^{2})	15 ± 1.8	15 ± 2.2	16.4 ± 2.8

[1]Values are n (%)
[2]Values are mean (standard deviation).

3.1. Pre-schoolers (Age 3-5 Years Old)

The average mean usual energy intake of stunted preschooler was significantly lower (867 kcal/d) than non-stunted preschoolers (1048 kcal/d) (Table 2). Furthermore, the mean energy intake of non- stunted and

stunted children were 10% and 15% lower than the EER, respectively (Figure 1).

The mean carbohydrate intake as a percentage of total energy was significantly higher for stunted preschoolers in contrast with the non-stunted preschoolers. All mean nutrient intakes of stunted preschoolers were significantly lower compared to the mean nutrient intakes of non-stunted preschoolers. Although a high prevalence of inadequacy was noticed for fiber, calcium, and iron intake for both groups, results showed that stunted preschoolers had a significantly higher prevalence of inadequacy compared to non-stunted preschoolers (Table 2). Also, the correlation test showed that DDS was positively correlated to the height-for-age Z-score (ρ=0.122, P<0.001) (Figure 2), and the chi-square test confirmed a significant association between the prevalence of stunting and DDS level (Table 5). The consumption of Meat, Pork, and Fish, Cereals, Roots, and Tubers and Dairy significantly differ between non-stunted and stunted preschoolers (Table 6).

3.2. Young Children (Age 6-9 Years Old)

In Table 3, the average mean usual energy intake of stunted young children was significantly lower (1126 kcal/d) than non-stunted young children (1289 kcal/d). Furthermore, the mean energy intake of non- stunted and stunted children were 19% and 18% higher than the EER, respectively (Figure 1).

The mean nutrient intakes of stunted young children were significantly lower compared to the mean nutrient intakes of non-stunted young children except for carbohydrates as a percentage of the total energy. Mean carbohydrate as a percentage of total energy was significantly higher for stunted young children as compared with non-stunted young children. For both groups, the inadequacy of calcium and iron was highly prevalent ranging from 70%-95% followed by vitamin C, folate, thiamin, and riboflavin with 42%-69%. However, stunted young children had a higher prevalence of inadequacy compared to non-stunted young children for all nutrients except for vitamin C and protein (Table 3). The correlation test showed that DDS was positively correlated to the height-for-age Z-score (ρ=0.094, P<0.001) (Figure 2), and the chi-square test showed a significant association between the prevalence of stunting and DDS level (Table 5). The consumption of Meat, Pork, and Fish and Cereals, Roots and Tubers, and Dairy significantly differ between non-stunted and stunted young school children (Table 7).

3.3. Older Children (Age 10-12 Years Old)

Also in Table 2, the average mean usual energy intake of stunted older children was significantly lower (1339 kcal/d) than non-stunted older children (1618 kcal/d). (Table 2). Furthermore, the mean EER of non- stunted older children (2020 kcal/d) was 25% higher compared to their average energy intake (1618 kcal/d) while the average EER of stunted older children (1716 kcal/d) was 28% higher compared to the mean energy intake (1339 kcal/d) (Figure 1).
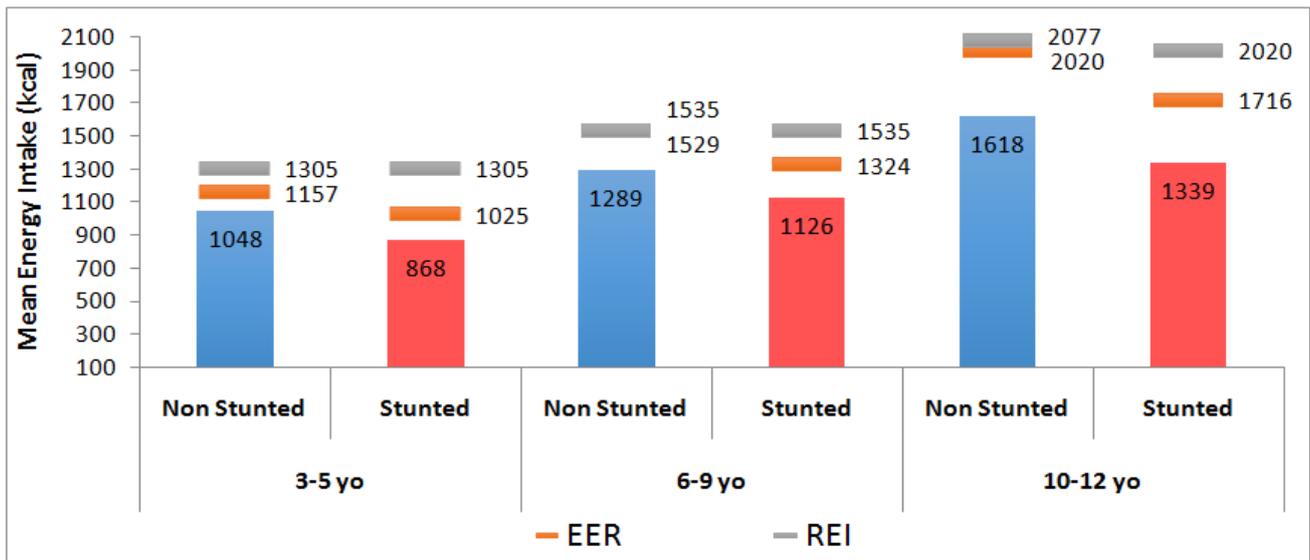
Table 2. Mean Usual Nutrient Intakes and Prevalence of Inadequacy for All 3-5 Year Old By Height Status

Nutrients	EAR/ AMDR[1]	Mean ± SE		Prevalence of Inadequacy	
		Non-stunted	Stunted	Non-stunted	Stunted
Sample, n		1642	735		
Macronutrients					
Energy (kcal/d)	-	1048 ± 28.2	867.6 ± 10.9*	-	-
Crude Protein (g/d)	17.5	33.2 ± 0.3	27.1 ± 0.4*	7	18*
Carbohydrate (g/d)	-	169.8 ± 1.4	149.1 ± 1.9*	-	-
As percentage of total energy					
Protein (%)	6-15[a]	12.8 ± 0.05	12.5 ± 0.1*	0	0
Carbohydrate (%)	55-79[a]	66.1 ± 0.2	74.6 ± 0.3*	10	5*
B vitamins					
Thiamine (mg/d)	0.4	0.6 ± 0.01	0.4 ± 0.01*	35	58*
Riboflavin (mg/d)	0.4	0.7 ± 0.01	0.4 ± 0.01*	33	62*
Niacin (mg/d)	5	9.5 ± 0.1	7.9 ± 0.1*	8	18*
Vitamin B6 (mg/d)	0.5	0.7 ± 0.01	0.6 ± 0.01*	27	42*
Vitamin B12 (mg/d)	0.9	2.1 ± 0.03	1.8 ± 0.04*	16	27*
Folate DFE (µg/d)	160	138.4 ± 1.7	121.1 ± 2.8*	69	76*
Bone-related nutrients					
Calcium (mg/d)	440	323.2 ± 5.5	217.4 ± 4.9*	79	94*
Phosphorus (mg/d)	405	525.3 ± 5.4	416.7 ± 6*	33	53*
Zinc (mg/d)	3.25	3.8 ± 0.04	3 ± 0.05*	43	66*
Other micronutrients					
Vitamin C (mg/d)	17	19.9 ± 0.5	16.8 ± 0.5*	54	63*
Iron (mg/d)	7.5	6 ± 0.1	4.7 ± 0.1*	75	89*
Magnesium (mg/d)	70[b]	97.6 ± 1.1	83.5 ± 1.3*	-	-

[1]Philippine Dietary Reference Intakes (PDRI) 2015 recommendations
[a]Values shown for protein and carbohydrates as percentage of total energy are AMDRs, not EAR.
[b]Value was the Recommended Nutrient Intake (RNI) not EAR.

Figure 1. Comparing the Usual Mean Energy Intake to the Estimated Energy Requirement (EER) and Recommended Energy Intake (REI) By Height Status. (Sources: Institute of Medicine and Philippine Dietary Reference Intakes)

Table 3. Mean Usual Nutrient Intakes and Prevalence of Inadequacy for All 6-9 Year Old By Height Status

Nutrients	EAR/ AMDR	Mean ± SE		Prevalence of Inadequacy	
		Non-stunted	Stunted	Non-stunted	Stunted
Sample, n		2507	1013		
Macronutrients					
Energy (kcal/d)	-	1289 ± 8.1	1126 ± 13.9*	-	-
Crude Protein (g/d)	24	40.3 ± 0.2	34.6 ± 0.4*	7	24*
Carbohydrate (g/d)	-	218 ± 1.4	202.7 ± 2.5*	-	-
As percentage of total energy					
Protein (%)	6-15[a]	12.7 ± 0.04	12.5 ± 0.06*	0	0
Carbohydrate (%)	55-79[a]	68.5 ± 0.1	72.5 ± 0.2*	4	2*
B vitamins					
Thiamine (mg/d)	0.55	0.6 ± 0.01	0.5 ± 0.01*	42	65*
Riboflavin (mg/d)	0.55	0.6 ± 0.01	0.5 ± 0.01*	51	72*
Niacin (mg/d)	7	12.3 ± 0.1	10.6 ± 0.1*	7	23*
Vitamin B6 (mg/d)	0.65	0.9 ± 0.01	0.8 ± 0.01*	22	41*
Vitamin B12 (mg/d)	1.15	2.5 ± 0.03	2.4 ± 0.05*	10	19*
Folate DFE (µg/d)	160	157.9 ± 1.6	150.9 ± 3.1*	59	65*
Bone-related nutrients					
Calcium (mg/d)	440	270 ± 2.4	226.4 ± 3.6*	91	95*
Phosphorus (mg/d)	405	606.1 ± 4	534.5 ± 6.8*	13	30*
Zinc (mg/d)	3.4	4.5 ± 0.04	3.7 ± 0.06*	31	52*
Other micronutrients					
Vitamin C (mg/d)	22.5	22.3 ± 0.3	19.7 ± 0.5*	69	61*
Iron (mg/d)	8.2	7.5 ± 0.1	6.1 ± 0.1*	70	81*
Magnesium (mg/d)	90[b]	122.2 ± 0.8	113.9 ± 1.5*	-	-

[1]Philippine Dietary Reference Intakes (PDRI) 2015 recommendations
[a]Values shown for protein and carbohydrates as percentage of total energy are AMDRs, not EAR.
[b]Value was the Recommended Nutrient Intake (RNI) not EAR.

The mean carbohydrates as a percentage of total energy were significantly higher for stunted older children compared to non-stunted children. All other mean nutrients were lower for stunted older children compared to non-stunted children. High prevalence of inadequacy of calcium, iron, vitamin C, phosphorus, folate, riboflavin, and thiamin intake was ascertained for both groups spanning from 56%-98%. Stunted older children were more inadequate for all nutrients except for protein, folate, and vitamin C as compared to non-stunted older children (Table 4). DDS remained positively associated with the height-for-age Z-score (ρ=0.096, P<0.001) (Figure 2) while the chi-square test showed no significant association between the prevalence of stunting and DDS level (Table 5). The consumption of Meat, Pork, and Fish and Cereals, Roots, and Tubers significantly differ between non-stunted and stunted older school children (Table 8).

Table 4. Mean Usual Nutrient Intakes and Prevalence of Inadequacy for All 10-12 Year Old By Height Status

Nutrients	EAR/ AMDR	Mean ± SE		Prevalence of Inadequacy	
		Non-stunted	Stunted	Non-stunted	Stunted
Sample, n		1981	936		
Macronutrients					
Energy (kcal/d)	-	1618 ± 11.7	1339 ± 15.2*	-	-
Crude Protein (g/d)	34.5	50.4 ± 0.4	41.2 ± 0.4*	16	34*
Carbohydrate (g/d)	-	282.2 ± 2.1	243.9 ± 2.9*	-	-
As percentage of total energy					
Protein (%)	6-15[a]	12.6 ± 0.04	12.5 ± 0.05*	0	0
Carbohydrate (%)	55-79[a]	70.6 ± 0.2	73.3 ± 0.2*	3	1*
B vitamins					
Thiamine (mg/d)	0.75	0.8 ± 0.01	0.6 ± 0.01*	56	81*
Riboflavin (mg/d)	0.8	0.7 ± 0.01	0.5 ± 0.01*	74	89*
Niacin (mg/d)	9.5	15.7 ± 0.1	12.7 ± 0.1*	11	25*
Vitamin B6 (mg/d)	0.9	1.1 ± 0.01	0.9 ± 0.01*	31	53*
Vitamin B12 (mg/d)	1.6	3 ± 0.03	2.9 ± 0.05*	14	18*
Folate DFE (µg/d)	250	185.3 ± 2.4	176.2 ± 4.2*	79	80[NS]
Bone-related nutrients					
Calcium (mg/d)	440	304.9 ± 2.8	254 ± 4*	88	92*
Phosphorus (mg/d)	1055	762.8 ± 5.7	634.8 ± 7.2*	87	95*
Zinc (mg/d)	4.25	5.7 ± 0.1	4.2 ± 0.05*	33	58*
Other micronutrients					
Vitamin C (mg/d)	34.5	23.5 ± 0.4	21 ± 0.5*	81	83[NS]
Iron (mg/d)	13.4	8.6 ± 0.1	6.6 ± 0.1*	90	98*
Magnesium (mg/d)	155[b]	156.1 ± 1.3	134.7 ± 1.7*	-	-

[1]Philippine Dietary Reference Intakes (PDRI) 2015 recommendations
[a]Values shown for protein and carbohydrates as percentage of total energy are AMDRs, not EAR.
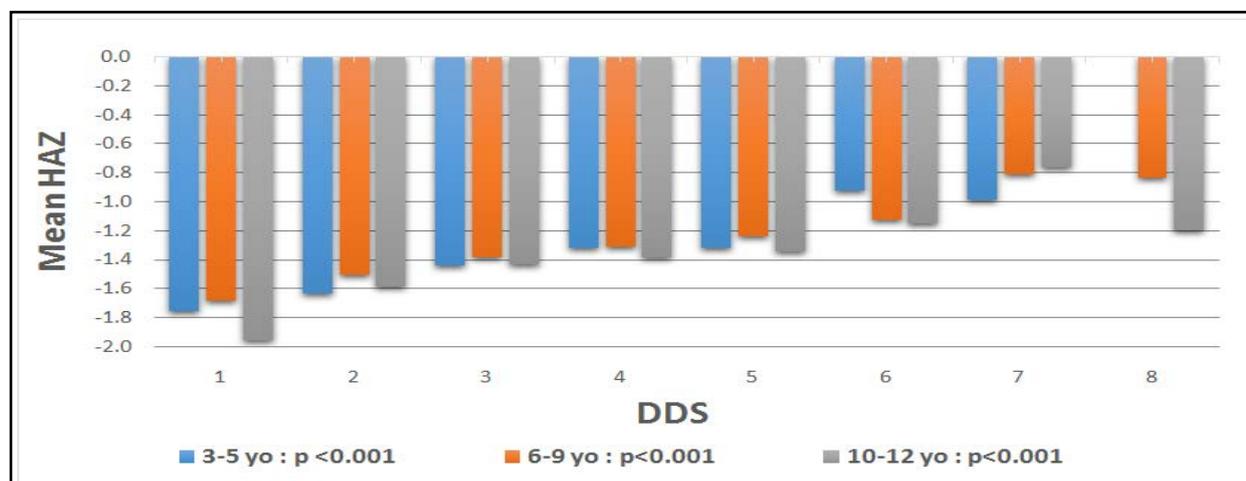[b]Value was the Recommended Nutrient Intake (RNI) not EAR.

Figure 2. Mean Height-For Age Z-Score by Dietary Diversity Score

Table 5. Dietary Diversity Score Level By Height Status

	Non-stunted	Stunted	p-value[2]
	n (% row)	n (% row)	n (% row)
3-5 years old			
High DDS (≥4)	510 (74.6)	174 (25.4)	0.000*
Low DDS (<4)	1132 (66.9)	561 (33.1)	
6-9 years old			
High DDS (≥4)	841 (74.4)	290 (25.6)	0.005*
Low DDS (<4)	1666 (69.7)	723 (30.3)	
10-12 years old			
High DDS (≥4)	736 (69)	332 (31)	0.376[NS]
Low DDS (<4)	1245 (67.3)	604 (32.7)	

[2]Chi-square Test for Association, *significant at α=0.05.

Table 6. Percentage Consuming and Food Group Intake of Preschoolers Aged 3-5 Years Old By Height Status

	Non-stunted (n=1647)		Stunted (n=740)		
Food Groups	Children Consuming, n (%)	Food Intake, g[1]	Children Consuming, n (%)	Food Intake, g[1]	p-value[2]
Cereals, roots and tubers	1645 (99)	157.2 (103, 226)	738 (99)	140.6 (95, 205)	0.007*
Meat, poultry, fish	1382 (84)	60.1 (30, 102)	577 (78)	44.1 (22, 71)	0.000*
Other vegetables	402 (24)	21.8 (12, 38)	209 (28)	21.1 (13, 32)	0.287
Eggs	448 (27)	35.2 (18, 55)	187 (25)	31 (18, 46)	0.187
Other fruits	260 (16)	53.1 (22, 108)	140 (19)	53.1 (23, 94)	0.928
Dairy	690 (42)	33 (19, 72)	169 (23)	28.2 (10, 48)	0.001*
Vitamin A rich fruits and vegetables	394 (24)	10 (5, 20)	222 (30)	11.7 (6, 21)	0.263
Legumes, pulses and nuts	290 (18)	17.5 (9, 33)	126 (17)	17.4 (9, 33)	0.739
Oils and Fats	1008 (61)	3.8 (2, 7)	408 (55)	3.6 (2, 7)	0.975

[1]Values are medians (25th, 75th percentiles)
[2] Wilcoxon rank-sum test, *significant at α=0.05.

Table 7. Percentage Consuming and Food Group Intake of Young School Children Aged 6-9 Years Old By Height Status

	Non-stunted (n=2511)		Stunted (n=1018)		
Food Groups	Children Consuming, n (%)	Food Intake, g[1]	Children Consuming, n(%)	Food Intake, g[1]	p-value[2]
Cereals, roots and tubers	2511 (100)	215.2 (164, 298)	1018 (100)	198.7 (140, 285)	0.001*
Meat, poultry, fish	2273 (90)	75.1 (40, 130)	834 (82)	59.5 (30, 104)	0.000*
Other vegetables	737 (29)	27.7 (14, 52)	305 (30)	28.4 (16, 55)	0.052
Eggs	726 (29)	35.2 (19, 55)	247 (24)	35.2 (21, 55)	0.65
Other fruits	406 (16)	53 (22, 111)	206 (20)	66.4 (26, 118)	0.094
Dairy	588 (23)	21.9 (12, 40)	125 (12)	18.8 (9, 33)	0.01*
Vitamin A rich fruits and vegetables	699 (28)	11.7 (6, 23)	348 (34)	12.7 (6, 27)	0.075
Legumes, pulses and nuts	469 (19)	18 (10, 36)	213 (21)	18.3 (13, 39)	0.254
Oils and Fats	1712 (68)	5 (3, 9)	599 (29)	5 (2, 8)	0.06

[1]Values are medians (25th, 75th percentiles)
[2] Wilcoxon rank-sum test, *significant at α=0.05.

Table 8. Percentage Consuming and Food Group Intake of Older School Children Aged 10-12 Years Old By Height Status

	Non-stunted (n=1988)		Stunted (n=937)		
Food Groups	Children Consuming, n (%)	Food Intake, g[1]	Children Consuming, %	Food Intake, g[1]	p-value[2]
Cereals, roots and tubers	1986 (99)	284.7 (199, 397)	936 (99)	245.9 (165, 351)	0.000*
Meat, poultry, fish	1811 (91)	96.4 (50, 157)	799 (85)	69.5 (35, 122)	0.000*
Other vegetables	668 (34)	32.6 (16, 64)	314 (33)	35.7 (19, 67)	0.265
Eggs	534 (27)	35.2 (20, 55)	218 (23)	35.2 (22, 55)	0.508
Other fruits	326 (16)	67.5 (31, 142)	198 (21)	64.3 (26, 106)	0.451
Dairy	330 (17)	19.9 (10, 46)	101 (11)	18.8 (10, 33)	0.105
Vitamin A rich fruits and vegetables	687 (34)	16.1 (7, 32)	339 (36)	16.4 (8, 35)	0.48
Legumes, pulses and nuts	422 (21)	26.2 (16, 51)	207 (22)	26.2 (13, 52)	0.712
Oils and Fats	1361 (68)	5.4 (3, 10)	585 (62)	5 (2,8)	0.168

[1]Values are medians (25th, 75th percentiles)
[2] Wilcoxon rank-sum test, *significant at α=0.05.

3.4. Logistic Regression Analysis

Table 9 - Table 11 shows the association between food group intakes, nutrient intakes, and the prevalence of stunting. For preschoolers, after adjustment children with higher intake of calcium (Q4) (OR=0.53, 95% CI: 0.38, 0.76) were less likely to become stunted compared to lowest calcium intake (Q1) (Table 9). For young school-aged children, risk of stunting was less frequent among children with higher intakes of crude protein (Q4) (OR=0.59, 95% CI: 0.41, 0.84) iron (Q4) (OR=0.67, 95% CI: 0.46, 0.97) and lower intake of magnesium (Q4) (OR=1.42, 95% CI: 1.02, 1.98) (Table 10). Compared to the lowest quartile of crude protein and thiamin intake (Q1), higher intake of protein and thiamin (Q4) was associated with 40% and 34% reduced odds of being stunted among older school-aged children after adjusting for potential confounders (sex, urbanity, wealth quintile) (OR=0.60, 95% CI: 0.42, 0.87) (OR=0.66, 95% CI: 0.45, 0.98) (Table 11).

Table 9. Adjusted Odds Ratio (OR) of the Estimated Usual Nutrient Intakes for Stunted Filipino Preschool Children Aged 3-5 Years Old, NNS 2013

Factors		Adjusted OR[1] (95% CI)	p-value
Sex	Male	1	-
	Female	1.08 (0.85, 1.35)	0.523
Urbanity	Rural	1	-
	Urban	0.96 (0.75, 1.24)	0.773
Wealth Tertiles	Poor	1	-
	Middle	0.46 (0.34, 0.61)	<0.001*
	Rich	0.24 (0.17, 0.34)	<0.001*
Calcium	Q1	1	-
	Q2	0.85 (0.61, 1.17)	0.318
	Q3	0.58 (0.42, 0.82)	0.002*
	Q4	0.53 (0.38, 0.76)	0.001*

Abbreviations: CI, confidence interval; OR, odds ratio.
[1]Using multiple logistic regression analysis adjusted for sex, urbanity, and wealth tertiles.
Note: Quartile 1 represents the lowest intake while Quartile 4 represents the highest intake.

Table 10. Adjusted Odds Ratio (OR) of the Estimated Usual Nutrient Intakes For Stunted Filipino Young School Children Aged 6-9 Years Old, NNS 2013

Factors		Adjusted OR[1] (95% CI)	p-value
Sex	Male	1	-
	Female	0.80 (0.68, 0.93)	0.010*
Urbanity	Rural	1	-
	Urban	0.80 (0.66, 0.94)	0.013*
Wealth Tertiles	Poor	1	-
	Middle	0.67 (0.53, 0.83)	<0.001*
	Rich	0.31 (0.24, 0.40)	<0.001*
Crude Protein	Q1	1	-
	Q2	0.65 (0.82, 0.83)	0.001*
	Q3	0.66 (0.49, 0.89)	0.006*
	Q4	0.59 (0.41, 0.84)	0.003*
Iron	Q1	1	-
	Q2	0.81 (0.63, 1.06)	0.125
	Q3	0.74 (0.54, 1.03)	0.070
	Q4	0.67 (0.46, 0.97)	0.036*
Magnesium	Q1	1	-
	Q2	1.12 (0.87, 1.42)	0.376
	Q3	1.12 (0.84, 1.48)	0.419
	Q4	1.42 (1.02, 1.98)	0.037*

Abbreviations: CI, confidence interval; OR, odds ratio.
[1]Using multiple logistic regression analysis adjusted for sex, urbanity, and wealth tertiles.
Note: Quartile 1 represents the lowest intake while Quartile 4 represents the highest intake.

Table 11. Adjusted Odds Ratio (OR) of the Estimated Usual Nutrient Intakes For Stunted Filipino Older School Children Aged 10-12 Years Old, NNS 2013

Factors		Adjusted OR[1] (95% CI)	p-value
Sex	Male	1	-
	Female	0.67 (0.56, 0.80)	<0.001*
Urbanity	Rural	1	-
	Urban	0.87 (0.71, 1.05)	0.157
Wealth Tertiles	Poor	1	-
	Middle	0.61 (0.48, 0.78)	<0.001*
	Rich	0.38 (0.31, 0.49)	<0.001*
Crude Protein	Q1	1	-
	Q2	0.94 (0.72, 1.21)	0.627
	Q3	0.66 (0.48, 0.90)	0.010*
	Q4	0.60 (0.42, 0.87)	0.007*
Thiamin	Q1	1	-
	Q2	0.95 0.72, 1.24)	0.696
	Q3	1.04 (0.75, 1.45)	0.797
	Q4	0.66 (0.45, 0.98)	0.040*

Abbreviations: CI, confidence interval; OR, odds ratio.
[1]Using multiple logistic regression analysis adjusted for sex, urbanity, and wealth tertiles.
Note: Quartile 1 represents the lowest intake while Quartile 4 represents the highest intake.

4. Discussion

This study aims to evaluate the association of usual nutrient and food intake of stunted children aged 3 to 12 years old and the risk of stunting. First, we found out that stunted children have significantly lower intakes of almost all key nutrients needed for growth and development and also a high prevalence of inadequacy than non-stunted children. Second, stunted children have lower consumption of Meat and Protein Food, Cereals Roots and Tubers, and Dairy and lack of food diversity than non-stunted children. Lastly, we found a highly significant association between the prevalence of stunting and intake of calcium for preschool children; and crude protein for young and older school-aged children. This association remained significant even after taking potential confounders into account.

Based on the WHO report, the most direct causes of stunting were inadequate nutrition and diseases which causes poor absorption of nutrients. Our results showed that stunted children have significantly low mean energy intake. According to the Food and Agriculture Organization of the United Nation (FAO) the prevalence of undernourishment (proportion of the population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normally active and healthy life) of the Philippines was

13.3% (i. e. 13.9 million people) in the year 2016-2018 [23]. Tessema, et al. found that linear growth failure in Ethiopian children was more likely to be associated with low-quality protein intake and inadequate energy intake [24]. During childhood, energy intake from carbohydrates, protein, and fats must be meeting the requirements because during these stages physical activity is increasing. Inadequate intake of energy will hamper the normal physiological growth of children. Also, stunting has a negative implication for the achievement of educational objectives and school performance [25,26]. Energy serves as fuel to the body for internal functions such as repairs, builds and maintains cells and body tissues, and external functions e.g. walking, eating, running, etc. Researchers claim that calorie was needed for basal metabolism, body composition, digestion and absorption, physical energy, and mental energy [27,28]. A study analyzed the influence of calorie intake on the human body stating that if the calorie level were too low, muscle mass is broken down for getting energy to support the daily activities, a process known as catabolism which can be very dangerous, the basal metabolic rate will begin to get lower after three days, and a state of discomfort, nutritional deficiencies, fatigue, and irritability is associated with this low level of calories [29].

Stunted children were more deficient for almost all nutrients compared to non-stunted children. Research studies found out that the mean intake of total protein, phosphorus, calcium, vitamin C, and zinc of stunted children was also significantly lower than those of their non-stunted counterparts [30,31]. Micronutrients are essential components of a high-quality diet and have an extreme impact on health. Even though nutrients were required in minuscule amount, these are the essential building blocks of healthy brains, bones, and bodies. Inadequate intake of such nutrients leads to micronutrient deficiencies [32]. Bone was strongly influenced not only by calcium, protein, phosphorus, magnesium, vitamin D, and fluoride but also by several other vitamins and minerals [33]. Sufficient dietary protein provides the amino acids required for muscle protein synthesis and lessens the risk of falls (e.g. Saropenia - loss of muscle strength and mass) [34,35]. A long term deficiency of calcium may increase chronic disease risk [36,37]. Zinc deficiency limits the growth of both animal and human studies [38,39,40]. Folic acid is essential during pregnancy to prevent neural tube defect to the child's early development and vitamin B12 deficiency may affect the fetal development through disruptions in myelination and inflammatory processes and continuous deficiency of both vitamins are associated with a higher risk of depression in adulthood. Vitamin B12 deficit may lead to acute neurological symptoms affecting the nervous system [41,42]. Scurvy was brought about by lack of vitamin C which describes as hemorrhage which can happen in practically any organ and bone development is adjusted and get weak [43]. Positive balance phosphorus along with calcium supports bone augmentation and maintenance [44].

Our study also showed that stunted children have low consumption of Meat, Pork, and Fish, Cereals, Roots and Tubers, and Dairy. A study conducted by Esfarjani, et al. claims that dietary patterns with high in protein (e.g. dairy, legumes, and meat products) and carbohydrates (e.g. fruits, sweets, and desserts) potentially associated with the declined risk of stunting [45]. Also, low consumption meat and dairy product were associated with the prevalence of stunting [46,47,48]. More than 90% were inadequate in calcium intake and a very low percentage of children consuming dairy. Dairy has an ample of calcium content. Dairy consumption should be recommended to increase in Filipino populations to improve the calcium intake and prevent osteoporosis or other bone-related diseases caused by calcium deficiency. Red meat contains essential nutrients such as protein, essential amino acids, vitamins, and minerals that are the most common nutrient shortages in the world, including vitamin A, iron, and zinc [49]. However, we should consider animal foods high in saturated fat and cholesterol like meat may have bad implications to our health [50]. Cereals, Roots, and Tubers provide carbohydrates and carbohydrate is the main source of energy that is needed for daily activities and the primary fuel source for your brain's high energy demands [51].

Higher calcium intake was a significant factor in reducing the risk of stunting for preschool children. Prevalence of calcium intake among Filipino toddlers was extremely high and rice and sweetened beverages were top 3 and 4 sources calcium. Three out of ten children aged 3-5 years old were consuming cow's milk (6). In our results, almost half (42%) of non-stunted preschoolers were consuming dairy while only 23% for stunted preschoolers. A study also supported our result that a low intake of calcium seems to significantly contribute to the high levels of stunting [52]. Dietary calcium and calcium supplementation resulted in higher bone mineral content (BMC), bone mineral density (BMD), and size-adjusted BMC of Gambian children and elderly (>50 years old) [53,54]. Consumption of milk, milk products, and other calcium-rich food such as small fish and shellfish must increase to reduce the risk of stunting.

Higher protein intake was a significant factor in reducing the risk of stunting during school age (6-9 years old and 10-12 years old). Low protein intake was a substantial risk factor for stunting in school-aged children [55]. Lee's study on dietary protein consumption patterns in countries in Southeast Asia with high rates of stunting indicated that the predominant staples in the Southeast Asian diet were rice and other cereals, low levels of usable protein, and lack of essential amino acids and micronutrients. [56]. Protein-energy malnutrition (PEM) was one of the major deficiency disorders and manifested by children for being underweight, wasted, and stunted resulting from inadequate intake of energy and/or protein-rich food [57]. Studies persistently proved that eating more protein leads to improved bone health [58,59,60,61]. High-quality protein food provides the amino acids which play a critical role in the body. Insufficient protein-quality food (animal-source and/or plant source) increased the risk of inadequate intake of protein and most micronutrients, especially children [62].

5. Strengths and Limitations

This study provides population-based sources of data on the food and nutrient intake of stunted school children which may contribute to the understanding of the still high prevalence of stunting in the country.

All nutrients were calculated based only on food and beverages consumed by children. Food supplements were not included in the analysis. The participant/mother/caregiver may not report the exact food amount during recall. About half of the updated food composition database was built by adopting data from the National Nutrient Database of the United States Department of Agriculture and some other nearby Asian countries. All these limitations may over- or underestimated the child's dietary consumption. However, with a large sample size with the corresponding survey weights and the right statistical tool applied in all the analyses to be nationally represented, these limitations have been reduced and the data could represent valuable national information.

6. Conclusion and Recommendation

Indeed, stunted children have low consumption of all key nutrients necessary for normal growth and development. This can be explained by low food diversity and poor nutrient-dense foods consumed by these children. We found that adherence to higher calcium and protein intake influenced the likelihood of the risk of being stunted among children. However, an appropriate recommendation for nutrient intake must be followed.

Based on the findings of the study it is recommended that healthcare professionals must intensify the implementation of educational and interventional programs to improve the children's health such as nutrition education (household and individual level), supplementation with additional protein and calcium sources, and fortification of foods with nutrients with a high prevalence of inadequacy; and long-term diversification of diet to dwindle the incidence of stunting.

7. Data Availability

The data used in this study were extracted from the 2013 National Nutrition Survey of FNRI. Data requests for access to these data should be made. For more details please follow this link http://enutrition.fnri.dost.gov.ph/site/home.php.

Conflicts of Interest

The authors declare that there is no conflict of interest in publishing this paper.

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References

[1] World Health Organization (WHO), "Stunting in a Nutshell," Available: https://www.who.int/nutrition/healthygrowthproj_stunted_videos/en/ [Accessed February 18, 2020].

[2] World Health Organization (WHO), "Global Nutrition Report," Available: https://globalnutritionreport.org/reports/global-nutrition-report-2018/conclusion-critical-steps-get-nutrition-track/ [Accessed February 18, 2020].

[3] United Nations International Children's Emergency Fund (UNICEF), "Malnutrition," Available: https://data.unicef.org/topic/nutrition/malnutrition/ [Accessed February 18, 2020].

[4] World Bank, "New Country Classifications by Income Level: 2018-2019," Available: https://blogs.worldbank.org/opendata/new-country-classifications-income-level-2018-2019 [Accessed February 18, 2020].

[5] Food and Nutrition Research Institute- Department of Science and Technology (FNRI-DOST), "Expanded National Nutrition Survey: Pre-school and School Children," Food and Nutrition Research Institute, Taguig City, Metro Manila, Philippines. 2015.

[6] Denney L., Angeles-Agdeppa, I., Capanzana, M. V., Toledo, M. B., Donohue, J., and Carriquiry, A., "Nutrient Intakes and Food Sources of Filipino Infants, Toddlers and Young Children are Inadequate: Findings from the National Nutrition Survey 2013," *Nutrients* 10(11) 1730. 2018.

[7] Angeles-Agdeppa I., Denney, L., and M.V, Capanzana, "Usual Energy and Nutrient Intakes and Food Sources of Filipino Children Aged 6-12 Years from the 2013 National Nutrition Survey," *Nestlé Nutrition Institute Workshop Series* 91: 111-122. 2019.

[8] Food and Nutrition Research Institute- Department of Science and Technology (FNRI-DOST), "Expanded National Nutrition Survey: Food Security," Food and Nutrition Research Institute, Taguig City, Metro Manila, Philippines. 2015.

[9] Food and Nutrition Research Institute- Department of Science and Technology (FNRI-DOST), "Philippine Nutrition Facts and Figures 2013: 8th National Nutrition Survey: Dietary Survey," Food and Nutrition Research Institute, Taguig City, Metro Manila, Philippines. 2015.

[10] Angeles-Agdeppa, I., Lenighan, Y.M., Jacquier, E.F., Toledo, M. B., and Capanzana M. V., "The Impact of Wealth Status on Food Intake Patterns in Filipino School-Aged Children and Adolescents," *Nutrients* 11(12):2910. 2019.

[11] Food and Nutrition Research Institute- Department of Science and Technology (FNRI-DOST), "Philippine Nutrition Facts and Figures 2013: 8th National Nutrition Survey: Anthropometric Survey," Food and Nutrition Research Institute, Taguig City, Metro Manila, Philippines. 2015.

[12] World Health Organization (WHO), "WHO Child Growth Standards," Geneva. Available: https://www.who.int/childgrowth/standards/Technical_report.pdf [Accessed February 18, 2020].

[13] World Health Organization (WHO), "Growth reference data for 5-19 years," Geneva. Available: https://www.who.int/growthref/en/ [Accessed February 18, 2020].

[14] Food and Nutrition Research Institute- Department of Science and Technology (FNRI-DOST), "Philippine Nutrition Facts and Figures 2013: 8th National Nutrition Survey: Overview," Food and Nutrition Research Institute, Taguig City, Metro Manila, Philippines. 2015.

[15] Lopez-Olmedo, N., Carriquiry A. L., Rodriguez-Ramirez S., Ramírez-Silva, I., Espinosa-Montero, J., Hernández-Barrera, L., Campirano, F., Martínez-Tapia, B., and Rivera, J. A., "Usual intake of added sugars and saturated fats is high while dietary fiber is low in the Mexican population," *The Journal of Nutrition* 46, 1856S-1865S. 2016.

[16] Institute of Medicine, National Academy of Science, "Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids," *The National Academies Press.* Washington, DC, USA. 2002.

[17] Kennedy, G., Ballard, T., and Dop, M., "Guidelines for Measuring Household and Individual Dietary Diversity," Rome: FAO. 2010.

[18] Bullecer, E. R., Rabuco, L. B., Aninao, D. A. B., De Roxas, R. C., Esguerra, J. C. A., Lim, P. R. U., and Malimban, R. C., "Dietary diversity score as an indicator of nutritional adequacy of diets among 16-19-year-old adolescents," *Acta Medica Philippina* 46. 28-33. 2012.

[19] Food and Nutrition Research Institute- Department of Science and Technology (FNRI-DOST), "Philippine Dietary Reference Intakes

2015," Food and Nutrition Research Institute, Taguig City, Metro Manila, Philippines. 2015.

[20] Carriquiry, A. L., "Assessing the Prevalence of Nutrient Inadequacy," *Public Health Nutrition* 2(1), 23-33. 1999.

[21] Yu, P., Denney, L., Zheng, Y, Vinyes-Pares, G., Reidy, K. C., Eldridge A. L., Wang, P., and Zhang, Y., "Food Groups consumed by infants and toddlers in urban areas of China," *Food and Nutrition Research*. 60(0) 30289. 2016.

[22] Zhang, Z., Cogswell, M. E., Gillespie, C., Fang, J., Loustalot, F., Dai, S., Carriquiry, A. L., Kuklina, E. V., Hong, Y., Merritt, R., and Yang, Q., "Association between Usual Sodium and Potassium Intake and Blood Pressure and Hypertension among U.S. Adults: NHANES 2005-2010," *PLos ONE* 8(10): e75289. 2013.

[23] Food and Agriculture Organization of the United Nation, "FAOSTAT". Available: http://www.fao.org/faostat/en/#country/171 [Accessed March 20, 2020].

[24] Tessema, M., Gunaratna, N. S., Brouwer, I. D., Donato, K., Cohen, J. L., McConnell, M., Belachew, T., Belayneh, D., and De Groote, H., "Associations among High-Quality Protein and Energy Intake, Serum Transthyretin, Serum Amino Acids and Linear Growth of Children in Ethiopia," *Nutrients* 10(11), 1776. 2018.

[25] Sunny, B. S., DeStavola, B., Dube, A., Kondowe, S., Crampin, A. C., Glynn, J. R.,"Does Early Linear Growth Failure Influence Later School Performance? A Cohort Study in Karonga District, Northern Malawi," *PLoS ONE* 13(11): e0200380. 2018.

[26] Haile, D., Nigatu, D., Gashaw, K., and Demelash, H., "Height for age Z score and Cognitive Function are Associated with Academic Performance among School Children Aged 8-11 Years Old," *Archives of Public Health* 74:17. 2016.

[27] Kollias, H., "Research Review: A Calorie Isn't a Calorie". Precision Nutrition. Available: https://www.precisionnutrition.com/digesting-whole-vs-processed-foods [Accessed March 21, 2020).

[28] Tomm, S., "Five Reason the Body Needs Energy". Healthy Eating. December 7, 2018. Available: https://healthyeating.sfgate.com/five-reasons-body-needs-energy-4673.html [Accessed on March 20, 2020].

[29] Doinea, M. "Analysis upon the Influence of Calorie Intake on the Human Body," *Body Building Science Journal*. Vol. 1. 2009.

[30] Gibson, R. S., Manger, M. S., Krittaphol, W., Pongcharoen, T., Gowachirapant, S., Bailey, K. B., and Winichagoon, P., "Does zinc deficiency play a role in stunting among primary school children in NE Thailand?," *British Journal of Nutrition* 97(1) 167-75. 2007.

[31] Alshammari, E., Suneetha, E., Adnan, M., Khan, S., Alazzeh, A., "Growth Profile and Its Association with Nutrient Intake and Dietary Patterns among Children and Adolescents in Hail Region of Saudi Arabia," *BioMed Research International* 1-9. 2017.

[32] United Nations International Children's Emergency Fund (UNICEF), "Nutrition". Available: https://www.unicef.org/nutrition/index_iodine.html [Accessed March 20, 2020].

[33] Palacios, C., "The Role of Nutrients in Bone Health, from A to Z," *Critical Reviews in Food and Nutrition*. 46. 621-8. 2006.

[34] Monma, Y., Niu, K., Iwasaki, K., Tomita, N., Nakaya, N., Hozawa, A., Kuriyama, S., Takayama, S., Seki, T., Takeda, T., Yaegashi, N., Ebihara, S., Arai, H., Nagatomi, R., and Tsuji, I., "Dietary patterns associated with fall-related fracture in elderly Japanese: a population based prospective study," *BMC Geriatrics.* 10: 31. 2010.

[35] Pasiakos, S. M., "Exercise and amino acid anabolic cell signaling and the regulation of skeletal muscle mass". *Nutrients* 4(7): 740-758. 2012.

[36] Peterlik, M., Boonen, S., Cross, H. S., Lamberg-Allardt, C., "Vitamin D and calcium insufficiency-related chronic diseases: an emerging world-wide public health problem," *International Journal of Environmental Research and Public Health* 6(10): 2585-2607. 2009.

[37] Boonen, S., Lips, P., Bouillon, R., Bischoff-Ferrari, H. A., Vanderschueren, D., and Haentjens, P., "Need for additional calcium to reduce the risk of hip fracture with vitamin d supplementation: evidence from a comparative meta-analysis of randomized controlled trials," *Journal of Clinical Endocrinology and Metabolism.* 92.(4):1415-1423. 2007.

[38] Prasad, A. S., "Discovery of human zinc deficiency: its impact on human health and disease," *Advance Nutrition* 4(2): 176-190. 2013.

[39] MacDonald, R. S., "The role of zinc in growth and cell proliferation," *Journal of Nutrition* 130(5S Suppl): 1500S-8S. 2000.

[40] Clegg, M. S., Hanna, L. A., Niles, B. J., and Keen, C. L., "Zinc deficiency-induced cell death," *IUBMB Life* 57(10): 661-669. 2005.

[41] Black, M. M., "Effects of vitamin B12 and folate deficiency on brain development in children," *Food and Nutrition Bulletin* 29(2 Suppl): S126-S131. 2008.

[42] Ankar, A. and Kumar, A., "Vitamin B12 Deficiency (Cobalamin)," In: *StatPearls.* Treasure Island (FL): StatPearl Publishing. 2020.

[43] Maxfield L. and Crane, J.S., "Vitamin C Deficiency (Scurvy)" In: *StatPearls.* Treasure Island (FL): StatPearls Publishing. 2020.

[44] Heaney, R. P., "Phosphorus nutrition and the treatment of osteoporosis," *Mayo Clinical Proceedings.* 79(1):91-97. 2004.

[45] Esfarjani, F., Roustaee, R., Mohammadi-Nasrabadi, F., and Esmaillzadeh, A., "Major Dietary Patterns in Relation to Stunting among Children in Tehran, Iran". *Journal of Health, Population and Nutrition* 31(2): 202-210.

[46] Black, R. E., Williams, S. M., Jones, I. E., and Goulding, A., "Children Who Avoid Drinking Cow Milk Have Low Dietary Calcium Intakes and Poor Bone Health," *American Journal of Clinical Nutrition* 76(3), 675-80. 2002.

[47] Taher, E., Elkoly, M., Zaghloul, S., and Mohhamed, H., "Predictors of Stunting among Children Attending the National Nutrition Institute in Egypt". *The Egyptian Journal of Community Medicine*. 2018. Vol. 36 No.1, 2018.

[48] Krebs, N. F., Mazariegos, M., Tshefu, A., Bose, C., Sami, N., Chomba, E., Carlo, W., Goco, N., Kindem, M., Wright, L. L., Hambidge, K. M., and Complementary Feeding Study Group, "Meat consumption is associated with less stunting among toddlers in four diverse low-income settings," *Food and Nutrition Bulletin 32*(3) 185-191. 2011.

[49] Klurfeld, D. M., "What is the role of meat in a healthy diet?" Animal Frontiers, Volume 8, Issue 3, Pages 5-10. 2018.

[50] United States Department of Agriculture (USDA), "Why is it important to make lean or low-fat choices from the Protein Foods Group?" Nutrients and health benefit. Available: https://www.choosemyplate.gov/eathealthy/protein-foods/protein-foods-nutrients-health [Accessed March 20, 2020].

[51] Pearson, K., "Medical Review: What are the Key Functions of Carbohydrates?" November 9, 2017 Available: https://www.healthline.com/nutrition/carbohydrate-functions [Accessed March 20, 2020).

[52] Van Stuijvenberg, M. E., Nel, J., Schoeman, S. E., Lombard, C. J., du Plessis, L. M., and Dhansay, M. A. "A. Low Intake of Calcium and Vitamin D is Associated with Stunting in 2-5-Year-Old Children from an Impoverished South African Community". *European Journal of Nutrition & Food Safety* 5(5): 459-460.

[53] Dibba, B., Prentice, A., Ceesay, M., Stirling, D. M., Cole, T. J., and Poskitt, E.,"Effect of calcium supplementation on bone mineral accretion in Gambian children accustomed to a low-calcium diet," *American Journal of Clinical Nutrition*. 71(2): 544-549. 2000.

[54] Tai, V., Leung, W., Grey, A., Reid, I. R., and Bolland, M. J., "Calcium intake and bone mineral density: systematic review and meta-analysis". *BMJ* 351: h4183. 2015.

[55] Ernalia, Y., Dwi, L., Suyanto, U., and Restuastuti, T., "Different Intakes of Energy and Protein in Stunted and Non-stunted Elementary School Children in Indonesia," *KnE Life Sciences*, pages 4(4): 556-62. 2018.

[56] Lee, D. E. R., "Children's Protein Consumption in Southeast Asia: Consideration of Quality as Well as Quantity of Children's Protein Consumption in Southeast Asia," *Wharton Research Scholars*. 115. 2014.

[57] Save The Children International, "Annual Review 2015," Available: https://resourcecentre.savethechildren.net/node/14970/pdf/save_the_children_annual_review_2015.pdf [Accessed March 20, 2020].

[58] Bonjour, J. P., "Dietary protein: an essential nutrient for bone health," *Journal of the American College of Nutrition* 24(6 Suppl):526S-36S. 2005.

[59] Kerstetter, J. E., Kenny, A. M. and Insogna, K. L., "Dietary protein and skeletal health: a review of recent human research," *Current Opinion in Lipidology* 22(1): 16-20. 2011.

[60] Shams-White, M. M., Chung, M., Du, M., Fu, Z., Insogna, K. L., Karlsen, M. C., LeBoff, M. S., Shapses, S. A., Sackey, J., Wallace, T. C., and Weaver, C. M., "Dietary protein and bone health: a systematic review and meta-analysis from the National Osteoporosis Foundation," *American Journal of Clinical Nutrition* 105(6):1528-1543. 2017.

[61] Munger, R. G., Cerhan, J. R., & Chiu, B. C., "Prospective study of dietary protein intake and risk of hip fracture in postmenopausal women," *American Journal of Clinical Nutrition* 69(1): 147-152. 1999.

[62] Wu, G., Fanzo, J., Miller, D. D., Pingali, P., Post, M., Steiner, J. L., and Thalacker-Mercer, A. E. "Production and supply of high-quality food protein for human consumption: sustainability, challenges, and innovations," *Annals of the New York Academy of Sciences*, *1321*, 1-19. 2014.