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Validation of selected 2021 infant and young child feeding indicators for appropriate complementary feeding in relation to dietary adequacy and anthropometric status

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ABSTRACT

Introduction: With the new set of 2021 infant and young child feeding (IYCF) indicators released by WHO and UNICEF, there is a need for its validation in the Philippine setting. The study evaluated the validity of cut-off points used for minimum dietary diversity and minimum feeding frequency in terms of micronutrient and energy intake adequacy, respectively, and minimum acceptable diet (MAD) in relation to anthropometric status. **Methods:** The study covered 8360 infants and young children aged 6-23.9 months with complete information on IYCF, anthropometric measurements, maternal information, and household characteristics from the 2018-2019 Expanded National Nutrition Survey (ENNS). Bivariate and correlation analyses using STATA version 15 (Corp LLC, Texas, USA 2017) were performed to determine the association of specific IYCF indicators: dietary diversity and feeding frequency with nutrient and energy intake adequacy, and MAD with anthropometric status. Sensitivity and specificity analyses were performed to evaluate the accuracy of dietary diversity score (DDS) and feeding frequency in identifying children with adequate nutrient and energy intakes, respectively. **Results:** Significant associations were found between DDS and micronutrient adequacy, and between feeding frequency and energy intake adequacy, regardless of breastfeeding status. A DDS of 5 and 6 and feeding frequency of 4-5 and 8 maximised sensitivity and specificity in identifying breastfed and non-breastfed children meeting 100% nutrient and energy adequacy, respectively. **Conclusion:** The selected 2021 complementary feeding indicators are practical guidelines to reflect dietary adequacy, but may not capture the entire process related to nutritional outcomes, especially stunting.

Keywords: complementary feeding, dietary diversity, meal frequency, minimum acceptable diet, nutritional status

INTRODUCTION

In the Philippines, half (49.8%) of the Filipino children aged 0-23 months are appropriately breastfed while receiving timely complementary foods (DOST-FNRI, 2022). Based on the 2018-2019 ENNS, only 11.7% of children 6.0-23.9 months old met the minimum acceptable diet (MAD), while only 21.6% met the minimum dietary diversity.

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Complementing these poor feeding practices, majority of infants 6-23 months old are inadequate in energy, iron, and vitamin A. Results revealed significant linear growth faltering and micronutrient deficiencies during the second six months of infancy when complementary foods are essential to provide sufficient diet for growth and development (DOST-FNRI, 2022).

Infant and young child feeding (IYCF) is a major component of the Philippines' nutrition programme as embodied in the Department of Health IYCF 2030 Strategic Plan and the Philippine Plan of Action for Nutrition (NNC, 2017). To assess and monitor the progress of feeding practices at the national and local levels, the Philippines' IYCF 2030 Strategic Plan included three IYCF core indicators of appropriate complementary feeding based on the 2008 guidelines: minimum dietary diversity (MDD), minimum meal frequency (MMF), and MAD. The MDD is intended as a proxy indicator for micronutrient adequacy, while the MMF is a proxy indicator for dietary energy adequacy.

However, in 2021, the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) released an updated version of the IYCF indicators. Among the revisions made was to include breast milk as an eighth food group in the MDD indicator. The 7-group MDD indicator in the 2008 version was technically correct in its focus on complementary foods, but required separate estimates for breastfed and non-breastfed children. Consequently, the dietary diversity score (DDS) cut-off was increased to five groups compared to the 2008 version, which used four out of seven food groups (WHO, 2021).

With this context, there is a need to evaluate the validity of these three selected 2021 complementary feeding indicators to ensure their sensitivity and specificity as they are currently used to set the national IYCF targets. Moreover, the use of the modified dietary diversity as an indicator of adequate nutrient intake remains under evaluation, particularly in developing countries like the Philippines. Evidence showed inconsistent results on the associations between complementary feeding indicators and child nutritional status (Ruel, 2017). Understanding the extent to which these complementary feeding indicators can predict nutritional outcomes may lead to a more accurate identification of young children at-risk.

Considering that MDD and MMF are used as proxy indicators, this study evaluated the new MDD, MMF, and MAD complementary feeding indicators in assessing micronutrient and energy adequacy of complementary food intake among Filipino children 6.0-23.9 months old. Specifically, it evaluated the validity of cut-off points used for MDD and MMF in terms of micronutrient and energy intake adequacy, respectively, and evaluated the MAD in relation to anthropometric status.

MATERIAL AND METHODS

Study design and study participants

The study analysed the existing IYCF data of children 6.0-23.9 months old from the 2018-2019 ENNS, which covered 79 provinces and highly urbanised cities (HUCs). The ENNS had a cross-sectional survey design which utilised the 2013 Master Sample of the Philippine Statistics Authority as its sampling design, which has been described in detail elsewhere (DOST-FNRI, 2022).

A total of 8360 infants and young children aged 6-23.9 months (4287 breastfed and 4073 non-breastfed children) with complete anthropometric, biochemical, dietary, and IYCF data were included in the study.

Measured outcomes

Complementary feeding practices

Three modified 2021 complementary feeding indicators were evaluated based on the dietary intake of the previous day: DDS/MDD, meal frequency/MMF, and MAD. DDS was calculated by adding up the number of food groups consumed by the child in the past 24-hour period. Meeting the MDD indicator was based on the consumption of at least five of the following eight food groups: 1) grains, roots and tubers; 2) legumes and nuts; 3) dairy products; 4) flesh foods; 5) eggs; 6) vitamin A-rich fruits and vegetables; 7) other fruits and vegetables; and 8) breast milk. To achieve MMF, breastfed infants aged 6-8 months and 9-23 months must have received solid, semi-solid or soft foods at least two and three times, respectively, in the previous day; while non-breastfed children 6-23 months old must have received solid, semi-solid, soft foods, or milk feeds at least four times the previous day. The MAD indicator is a composite of the MDD and MMF indicators. Breastfed children must have received MDD and MMF the previous day, while non-breastfed children must have received at least two milk feedings and met the MDD and MMF during the previous day.

Individual dietary intake

A 24-hour food recall was conducted among the mothers or caregivers of children 6-23.9 months old via face-to-face interview to recall all foods and beverages that the child consumed on the previous day. To estimate the amount of each food item or beverage consumed, measuring tools such as cups, tablespoons, wooden matchboxes, and plastic circles were utilised. The Individual Dietary Evaluation System containing the updated Food Composition Table, which includes human milk (DOST-FNRI, 2019), was used to estimate the energy, protein, and micronutrient (iron, zinc, calcium, vitamin A, vitamin C, thiamin, riboflavin, and niacin) intakes of each child.

Dietary energy, protein, and micronutrient adequacies of each child's intake on the previous day were assessed using the 2015 Philippine Dietary Reference Intakes (PDRI) (DOST-FNRI, 2015). For iron, zinc, calcium, vitamin A, vitamin C, thiamin, riboflavin, and niacin, an aggregated mean percent micronutrient adequacy was obtained by adding the mean percent adequacy of each of the eight micronutrient adequacy and divided by eight micronutrients.

Child anthropometry

Anthropometric measurements (weight and height/length) were assessed using the WHO Child Growth Standards to determine the nutritional status of children (WHO, 2006).

Socioeconomic and demographic variables

The ENNS data on household economic status, place of residence, age, education, and working status of mothers were culled to describe the children's households. Wealth index was determined through principal component analysis of variables such as household characteristics, household assets, infrastructure factors, and utility access. Food security status was assessed using the Household Food Insecurity Access Scale questionnaire.

Statistical analysis

Statistical Analysis Stata 15 (Stata Corporation, Texas, USA 2017) was used for all statistical analyses. Mean and standard errors of selected complementary feeding indicators (DDS, meal frequency), energy, and nutrient intakes of children aged 6-23 months were estimated. The proportion of children meeting the MDD, MMF, MAD, recommended energy intake

(REI), nutrient's estimated average requirements (EAR), prevalence of undernutrition, and household food insecurity were generated.

Normality test was done for all continuous variables using the Shapiro-Wilk test. Since data on mean percentage adequacy (MPA) and energy adequacy were not normally distributed, correlation coefficients between dietary diversity vs. MPA and meal frequency vs. percent energy adequacy were assessed using Spearman's rank correlation test. Mann-Whitney U and Kruskal-Wallis tests were computed to determine the difference between medians from two and more than two independent groups/ categories, respectively.

MPA was used as the gold standard to evaluate DDS for sensitivity and specificity, while energy adequacy was used for meal frequency. Sensitivity and specificity analyses were performed to determine the accuracy of DDS and meal frequency in correctly classifying children with high MPA values and percent energy adequacy, respectively. To show what the generated DDS and MMF cut-off points could achieve in terms of nutrient and energy adequacy, three MPA and percent energy adequacy cut-off values were used in this analysis: 50%, 75%, and 100%. DDS and meal frequency cut-off points were identified based on the maximum sensitivity and specificity values. Area under the receiver operating characteristic curve (AUC) was computed using the ROCTAB command of Stata. The AUC was used to measure the accuracy of the diagnostic tests performed and AUC >0.7 was considered acceptable.

P-values <0.05 were considered statistically significant. All analyses were accounted for sampling weights to reflect nationally representative results.

Ethical approval

The study was conducted in accordance with the declaration of Helsinki and the protocol was approved by the Department of Science and Technology-Food and Nutrition Research Institute Ethics Review Committee on July 9, 2021 with FIERC#2021-022. All surveyed households including their members provided informed consent prior to participation.

RESULTS

General characteristics, feeding practices, and dietary intake of study population

Table 1 shows the characteristics of study children and their mothers, including their households' socio-demographic and economic status, as well as their feeding practices and dietary intake. The mean age of children was 15.3±0.1 months, of which breastfed and non-breastfed children had mean ages of 14.2±0.1 months and 16.4±0.1 months, respectively. There was an equal proportion of children between the age groups of 6-11 months (31.3%), 12-17 months (33.4%), and 18-23 months (35.3%). Majority (87.0%) of children had normal birth weight. There was an almost equal representation of boys and girls. By nutritional status, 28.1% were stunted, 16.8% were underweight, while 6.1% were wasted. There were more stunted, underweight, and wasted breastfed than non-breastfed children, while there were more overweight non-breastfed than breastfed children.

The mean age of mothers was 29.6±0.1 years. Most mothers were ≥20 years old (94.2%). More than half (56.7%) reached at least secondary level of education. Majority of mothers (75.5%) were not working at the time of survey. There was a higher proportion of non-breastfed children than breastfed children whose mothers had reached at least tertiary education (29.0% vs. 18.4%) and were working (33.1% vs. 16.9%). There were

Table 1. General and household characteristics of children 6-23 months old and their mothers, and feeding practices, food consumption, and dietary intake adequacy of children, Philippines: 2018-2019

Variables	*All children (n=8,360)*		*Breastfed children (n=4,285)*		*Non-breastfed children (n=4,073)*	
	n	*Proportion/ Mean±SE*	*n*	*Proportion/ Mean±SE*	*n*	*Proportion/ Mean±SE*
Child's characteristics						
Sex						
Boys	4302	50.5±0.6	2154	49.7±0.9	2148	51.2±1.2
Girls	4056	49.5±0.6	2131	50.3±0.9	1925	48.8±1.2
Mean age (in months)	8358	15.3±0.1	4285	14.2±0.1	4073	16.4±0.1
6-11	2643	31.3±0.7	1702	39.4±1.5	941	23.2±0.8
12-17	2751	33.4±0.7	1456	34.3±1.2	1295	32.6±1.0
18-23	2964	35.3±0.6	1127	26.3±0.9	1837	44.2±1.1
Birth weight (g)						
<2500	909	13.0±0.8	442	11.7±0.7	467	14.3±1.1
≥2500	6324	87.0±0.8	3318	88.3±0.7	3006	85.7±1.1
Nutritional status						
Underweight (%)	8358	16.8±0.6	4285	21.3±0.9	4073	12.4±0.8
Stunted (%)	8358	28.1±1.2	4285	31.3±1.5	4073	24.9±1.6
Wasted (%)	8358	6.1±0.5	4285	7.0±0.7	4073	5.1±0.6
Overweight/Obese (%)	8358	2.4±0.3	4285	1.7±0.3	4073	3.1±0.4
Maternal characteristics						
Age (years)	7415	29.6±0.1	4067	29.8±0.1	3348	29.4±0.2
<20	453	5.8±0.3	256	6.0±0.4	197	5.7±0.6
20-29	3692	49.0±0.9	1971	47.5±1.3	1721	50.7±1.4
≥30	3270	45.2±0.9	1840	46.6±1.1	1430	43.6±1.5
Education						
No education	93	1.1±0.2	71	1.6±0.3	22	0.5±0.2
Elementary	1414	17.7±1.2	921	21.2±1.3	493	13.8±1.2
At least high school	4040	56.7±1.1	2266	57.6±1.4	1774	55.7±1.1
At least college	1777	23.4±1.1	761	18.4±1.1	1016	29.0±1.5
Others	91	1.1±0.2	48	1.2±0.2	43	1.0±0.2
Currently working (%)						
Working	1730	24.5±1.4	673	16.9±0.9	1057	33.1±2.1
Not working	5685	75.5±1.4	3394	83.1±0.9	2291	66.9±2.1
Household characteristics						
Residence						
Rural	5483	56.4±3.8	2992	61.1±3.8	2491	51.7±3.9
Urban	2875	43.6± 3.8	1293	38.9±3.8	1582	48.3±3.9
Wealth status						
Poorest	2702	26.8±2.2	1637	32.7±2.4	1065	20.9±2.2
Poor	2055	23.5±1.3	1124	25.7±1.4	931	21.4±1.6
Middle	1510	19.4±0.9	730	18.6±1.1	780	20.3±1.1
Rich	1171	17.0±1.3	470	13.7±1.0	701	20.3±1.7
Richest	910	13.2±1.3	319	9.3±1.2	591	17.1±1.5

Table 1. General and household characteristics of children 6-23 months old and their mothers, and feeding practices, food consumption, and dietary intake adequacy of children, Philippines: 2018-2019 *(continued)*

Variables	*All children (n=8,360)*		*Breastfed children (n=4,285)*		*Non-breastfed children (n=4,073)*	
	n	*Proportion/ Mean±SE*	*n*	*Proportion/ Mean±SE*	*n*	*Proportion/ Mean±SE*
Food security[†]						
Severely food insecure	1645	29.6±1.3	740	26.1±1.4	905	33.0±1.5
Moderately food insecure	837	14.4±0.8	431	14.6±1.0	406	14.3±1.0
Mildly food insecure	2385	38.0±1.6	1296	40.0±1.7	1089	35.9±1.9
Food secure	1100	18.0±1.4	603	19.3±1.4	497	16.8±1.6
Current type of feeding practices						
Breastfeeding+ complementary feeding	3658	41.7±1.2	3658	83.8±0.8	0	0.0
Breastfeeding+ complementary feeding+ other milk	627	8.1±0.4	627	16.2±0.8	0	0.0
Other milk + semi-solid/ soft foods	4073	50.3±1.3	0	0.0	4073	100.0
Dietary diversity score (DDS)						
Mean DDS±*SE*	8358	3.1±0.0	4285	3.3±0.0	4073	2.9±0.0
Meeting minimum dietary diversity, %	8358	11.9±0.6	4285	15.9±0.9	4073	8.0±0.7
Proportion of children by DDS, %						
1	248	2.7±0.3	31	0.5±0.1	217	4.9±0.4
2	2735	32.1±0.9	1322	29.5±1.3	1413	34.6±1.2
3	2699	32.0±0.8	1377	31.6±1.3	1322	32.3±0.9
4	1706	21.3±0.8	920	22.5±0.9	786	20.2±1.1
5	734	8.8±0.4	463	11.2±0.6	271	6.5±0.5
6	220	2.9±0.2	159	4.4±0.4	61	1.4±0.3
7	16	0.2±0.1	13	0.4±0.1	3	0.1±0.0
8	0	0.0	0	0.0	0	0.0
Meal frequency						
Mean meal frequency±*SE*	8358	5.8±0.1	4287	4.0±0.0	4073	7.6±0.1
Meeting minimum meal frequency, %	8358	93.0±0.6	4285	89.3±1.2	4073	96.6±0.4
Proportion of children by meal frequency, %						
2	574	7.3±0.6	563	14.4±1.3	11	0.4±0.1
3	1428	15.1±0.9	1277	27.3±1.4	151	3.0±0.4
4	1387	16.0±0.8	1116	25.7±1.0	271	6.4±0.5
5	1259	14.6±0.7	754	17.7±0.9	505	11.5±1.1
≥6	3710	47.0±1.7	575	14.9±0.9	3135	78.8±1.7

Table 1. General and household characteristics of children 6-23 months old and their mothers, and feeding practices, food consumption, and dietary intake adequacy of children, Philippines: 2018-2019 *(continued)*

Variables	*All children (n=8,360)*		*Breastfed children (n=4,285)*		*Non-breastfed children (n=4,073)*	
	n	*Proportion/ Mean±SE*	*n*	*Proportion/ Mean±SE*	*n*	*Proportion/ Mean±SE*
Meeting minimum acceptable diet (MAD), %	8358	11.0±0.6	4285	15.7±0.9	4073	6.4±0.6
6-8 months	1231	1.5±0.4	800	2.1±0.6	431	0.5±0.3
9-23 months	7127	12.6±0.6	3485	18.7±1.1	3642	7.1±0.7
Consumption across food groups						
Grains, %	8358	96.7±0.5	4285	97.8±0.5	4073	95.7±0.5
Legumes, %	8358	5.6±0.6	4285	5.8±0.7	4073	5.3±0.5
Milk and dairy, %	8358	64.2±1.2	4285	34.9±1.3	4073	93.2±0.7
Flesh meat, %	8358	40.0±1.0	4285	37.4±1.1	4073	42.5±1.6
Eggs, %	8358	19.7±0.8	4285	18.4±1.0	4073	20.9±0.8
Fruits and/or vegetables, %	8358	29.3±0.8	4285	28.8±0.9	4073	29.8±1.2
Eggs, and/or flesh foods, %	8358	49.1±1.1	4285	46.4±1.2	4073	51.7±1.4
Consumption of unhealthy food						
Sweetened beverages, %	8358	5.0±0.4	4285	4.3±0.5	4073	5.7±0.6
No fruits and vegetables, %	8358	70.7±0.8	4285	71.2±0.9	4073	70.2±1.2
Dietary adequacy						
Energy						
Mean intake (kcal)	8358	777±8.0	4285	688±7.0	4073	865±11
Mean adequacy, %	8358	90.6±0.9	4285	82.6±0.9	4073	98.5±1.4
Meeting 100% adequacy, %	8358	31.0±0.9	4285	22.0±1.0	4073	39.8±1.4
Protein						
Mean adequacy, %	8358	169.8±3.0	4285	113.6±1.8	4073	225.3±3.7
Meeting 100% adequacy, %	8358	64.0±1.0	4285	43.5±1.3	4073	84.3±1.0
Iron						
Mean adequacy, %	8358	61.5±2.3	4285	36.0±1.2	4073	86.8±3.1
Meeting 100% adequacy, %	8358	20.3±1.3	4285	6.6±0.7	4073	33.8±1.7
Calcium						
Mean adequacy, %	8358	147.7±4.7	4285	70.5±1.7	4073	224.1±6.2
Meeting 100% adequacy, %	8358	44.8±1.4	4285	17.7±0.9	4073	71.7±1.7
Vitamin A						
Mean adequacy, %	8358	183.6±4.7	4285	134.2±4.2	4073	232.5±8.0
Meeting 100 % adequacy, %	8358	50.0±1.0	4285	43.4±1.3	4073	56.5±1.2

Table 1. General and household characteristics of children 6-23 months old and their mothers, and feeding practices, food consumption, and dietary intake adequacy of children, Philippines: 2018-2019 *(continued)*

Variables	*All children (n=8,360)*		*Breastfed children (n=4,285)*		*Non-breastfed children (n=4,073)*	
	n	*Proportion/ Mean±SE*	*n*	*Proportion/ Mean±SE*	*n*	*Proportion/ Mean±SE*
Vitamin C						
Mean adequacy, %	8358	185.7±8.9	4285	62.9±3.3	4073	307.2±13.2
Meeting 100 % adequacy, %	8358	45.0±1.4	4285	17.8±0.8	4073	71.8±1.7
Zinc						
Mean adequacy, %	8358	119.8±3.6	4285	65.3±1.6	4073	173.7±4.5
Meeting 100% adequacy, %	8358	42.1±1.5	4285	17.5±1.0	4073	66.4±1.7
Thiamin						
Mean adequacy, %	8358	105.3±2.5	4285	55.0±2.1	4073	155.1±2.7
Meeting 100% adequacy, %	8358	38.9±1.4	4285	14.5±0.9	4073	63.0±1.6
Riboflavin						
Mean adequacy, %	8358	201.7±5.1	4285	78.8±2.5	4073	323.3±8.5
Meeting 100% adequacy, %	8358	51.4±0.9	4285	22.9±1.0	4073	79.6±1.4
Niacin						
Mean adequacy, %	8358	122.1±4.7	4285	63.5±2.0	4073	180.1±7.1
Meeting 100% adequacy, %	8358	37.8±1.4	4285	18.5±0.9	4073	56.8±2.4
Mean percentage adequacy						
Mean adequacy, %	8358	65.6±0.8	4285	49.5±0.7	4073	81.5±1.0

[†]Food security was assessed using Household Food Insecurity Access Scale (HFIAS)

more children from rural (56.4%) than urban (43.6%) households. About one-third (29.6%) of children belonged to severely food insecure households and half of the study children were from the poor (23.5%) and poorest households (26.8%).

Majority (83.8%) of breastfed children were currently receiving complementary foods, while 16.2% were given complementary foods plus breast milk substitute. All non-breastfed children received semi-solid or soft foods at the time of survey. The mean DDS was 3.1±0.0, regardless of breastfeeding status. Among breastfed and non-breastfed children, mean DDS were 3.3±0.0 and 2.9±0.0, respectively. Majority (88.1%) of the children consumed less than the recommended five food groups per day, about two-thirds received 2-3 food groups, while only 11.9% met the MDD of five or more food groups in their diets (16.0% among breastfed, and 8.0% among non-breastfed children).

The children received about six (5.8±0.10) feedings per day (including meals plus snacks, but not including breast milk for breastfed children and

including milk feedings for non-breastfed children). Nearly all (93.0%) children met the MMF recommendations; non-breastfed children had a mean feeding frequency of 7.6±0.1 (96.6% met the MMF) and 4.0±0.0 (89.3% met the MMF) among the breastfed. By meal frequency, 14.4% and 27.3% of breastfed children received two and three feedings, respectively, while majority (96.7%) of non-breastfed children received ≥4 feedings per day, implying that most children received more than the recommended feedings.

However, most (89.0%) children failed to receive the MAD. This improved significantly with age from 6-8 months (1.5%) to 9-23 months (12.6%), regardless of breastfeeding status. By breastfeeding status, 15.7% and 6.4% of breastfed and non-breastfed children met the MAD, respectively.

The diet of infants and young children reflected a limited range of food group intakes. Nearly all (96.7%) children consumed foods from the "grain products, roots and tubers" group. Nutrient-dense animal source foods like milk and dairy were consumed higher (64.2%) than meat (40.0%) and eggs (19.7%). Milk and dairy products were consumed by the majority (93.2%) of non-breastfed children, while only 34.9% among breastfed children. Non-breastfed children consumed slightly more meat (42.5%) and eggs (20.9%) than breastfed children (37.4% and 18.4%, respectively). Low consumption of fruits and/or vegetables (29.3%) was observed, with almost similar consumption pattern among non-breastfed and breastfed children. Alarmingly, majority (70.7%) of children did not consume any fruits and vegetables, and about 5.0% consumed sweetened beverages.

In terms of dietary and nutrient adequacies, the mean energy intake of children was 777 kcal/day, with 90.6% mean energy adequacy, but only 31.0% of children met the REI. Protein intake of children had >100% mean adequacy with about two-thirds (64.0%) meeting the protein requirement. The MPA was 65.6%. When disaggregated, mean iron adequacy was only 61.5%, while calcium, vitamin A, vitamin C, zinc, thiamin, riboflavin, and niacin had >100% mean adequacies. However, all eight key micronutrients had low proportion of children meeting the EARs.

By breastfeeding status, there were higher proportions of non-breastfed than breastfed children meeting the daily requirements for energy (39.8% vs. 22.0%), protein (84.3% vs. 43.5%), and eight key micronutrients. Likewise, non-breastfed children had a higher mean energy adequacy (98.5%) than breastfed children (82.6%). Mean protein and micronutrient adequacies were >100% in non-breastfed children, except for iron (86.8%), while only protein and vitamin A had >100% mean adequacies among breastfed children, with iron having the lowest mean adequacy (36.0%). The MPA among breastfed and non-breastfed children were 49.5% and 81.5%, respectively.

Association between dietary diversity and micronutrient adequacy

Table 2 presents the association of DDS and feeding frequency to dietary intakes of study children. Median MPA of all children was 70.3%. Median MPA increased with DDS, and it was significantly higher at DDS ≥5 (DDS 5: 79.2% and DDS >5: 84.8%) than DDS <5 (68.1%; $p<0.001$). This pattern was observed regardless of breastfeeding status. However, higher median MPA was consistently observed among non-breastfed than breastfed children ($p<0.001$). Significant correlation was seen between DDS and MPA; it was positively moderate in breastfed ($r_s=0.55$) and positively very weak in non-breastfed ($r_s=0.08$) ($p<0.001$) children.

To assess whether the 2021 IYCF

Table 2. Associations of dietary diversity score and meal frequency to dietary intakes of children 6-23 months old, Philippines: 2018-2019

Dietary Intake	*All children*				*Breastfed children (Bf)*				*Non-breastfed children (NBf)*				*Bf vs. NBf (p-value)*
	Median	*SD*	r_s [§]	*p-value*	*Median*	*SD*	r_s [§]	*p-value*	*Median*	*SD*	r_s [§]	*p-value*	
Dietary Diversity Score[†]													
Mean percentage adequacy, %	70.3	27.7	0.187	<0.001[§*]	42.6	24.9	0.554	<0.001[§*]	87.0	20.2	0.075	<0.001[§*]	<0.001[b*]
DDS													
<5	68.1	28.2	-	<0.001[a*]	38.3	23.7	-	<0.001[a*]	86.6	20.6	-	0.038[a*]	<0.001[b*]
5	79.2	21.0	-		67.6	21.4	-		90.4	14.8	-		<0.001[b*]
>5	84.8	18.1	-		70.0	18.4	-		92.3	12.8	-		<0.001[b*]
Feeding frequency[‡]													
Energy													
Total intake (kcal)	667	374	0.501	<0.001[§*]	614	259	0.615	<0.001[§*]	761	451	0.430	<0.001[§*]	<0.001[b*]
Feeding frequency													
2	462	98	-	<0.001[a*]	463	90	-	<0.001[a*]	277	290	-	<0.001[a*]	0.005[b*]
3	536	175	-		546	155	-		385	276	-		<0.001[b*]
4	621	241	-		641	211	-		498	321	-		<0.001[b*]
5	700	275	-		736	248	-		637	298	-		<0.001[b*]
≥6	840	445	-		907	337	-		821	461	-		<0.001[b*]
Percent energy adequacy, %													
Age group													
6-23 months	79.3	44.0	0.430	<0.001[§*]	75.7	31.4	0.461	<0.001[§*]	85.2	53.3	0.492	<0.001[§*]	<0.001[b*]
Feeding frequency													
2	64.2	16.3	-	<0.001[a*]	64.4	15.6	-	<0.001[a*]	30.1	30.7	-	<0.001[a*]	<0.001[b*]
3	67.3	24.8	-		69.4	22.5	-		41.6	33.6	-		<0.001[b*]
4	74.0	29.6	-		77.4	26.6	-		51.7	35.0	-		<0.001[b*]
5	80.0	31.9	-		87.0	29.2	-		68.0	32.4	-		<0.001[b*]
≥6	96.0	52.8	-		105.2	43.2	-		94.0	54.3	-		<0.001[b*]

Table 2. Associations of dietary diversity score and meal frequency to dietary intakes of children 6-23 months old, Philippines: 2018-2019 *(continued)*

Dietary Intake	*All children*				*Breastfed children (Bf)*				*Non-breastfed children (NBf)*				*Bf vs. NBf (p-value)*
	Median	*SD*	r_s §	*p-value*	*Median*	*SD*	r_s §	*p-value*	*Median*	*SD*	r_s §	*p-value*	
6-8 months	86.6	48.1	0.480	<0.001§*	82.0	31.4	0.605	<0.001§*	102.4	65.9	0.391	<0.001§*	<0.001[b]*
Feeding frequency													
2	71.0	12.1	-	<0.001[a]*	71.0	12.1	-	<0.001[a]*	00.0	00.0	-	<0.001[a]*	-
3	80.6	19.6	-		80.8	18.9	-		39.7	20.9	-		0.002[b]*
4	87.5	35.6	-		87.8	35.4	-		72.5	29.8	-		0.023[b]*
5	99.6	29.9	-		101.9	24.8	-		80.0	49.5	-		0.006[b]*
≥6	109.1	64.6	-		127.6	53.3	-		103.9	66.0	-		0.002[b]*
9-23 months	77.8	43.0	0.455	<0.001§*	73.8	31.1	0.509	<0.001§*	83.2	51.1	0.492	<0.001§*	<0.001[b]*
Feeding frequency													
2	56.0	16.0	-	<0.001[a]*	56.4	15.0	-	<0.001[a]*	30.1	30.7	-		<0.001[b]*
3	62.4	24.4	-		64.0	21.8	-		41.7	34.0	-		<0.001[b]*
4	71.1	27.9	-		74.6	24.0	-		51.5	35.2	-	<0.001[a]*	<0.001[b]*
5	78.0	31.5	-		84.5	29.1	-		67.4	31.9	-		<0.001[b]*
≥6	94.2	50.5	-		102.6	41.0	-		92.2	52.1	-		<0.001[b]*

[†]Dietary diversity score was determined based on the eight (8) food groups in the 2021 WHO-IYCF guidelines: breast milk, grains, roots and tubers and plantains, dairy products, legumes and nuts, flesh foods, eggs, vitamin-A rich fruits and vegetables, and other fruits and vegetables.

[‡]Feeding or meal frequency is the number of feedings received by the child in the previous day. It includes milk feedings among non-breastfed children.

[§]Based on Spearman's correlation coefficient

[a]Based on Kruskal-Wallis Test

[b]Based on Mann-Whitney U test

*Significant at $p<0.05$

Table 3. Area under the curve (AUC) analysis of dietary diversity score among children 6-23 months old, Philippines: 2018-2019

Dietary diversity score	*Mean percentage adequacy (MPA) cut-off*											
	MPA: ≥50%				*MPA: ≥75%*				*MPA: ≥100%*			
	Cut-off	*Sensitivity*	*Specificity*	*AUC*†	*Cut-off*	*Sensitivity*	*Specificity*	*AUC*†	*Cut-off*	*Sensitivity*	*Specificity*	*AUC*†
All children	4	0.39	0.80	0.59	4	0.36	0.72	0.54	6	0.03	0.97	0.50
Breastfed children	4	0.58	0.79	0.69	4	0.61	0.70	0.65	5	0.31	0.86	0.58
Non-breastfed children	3	0.62	0.56	0.59	4	0.30	0.78	0.54	6	0.02	0.98	0.50

†Area under receiving operating characteristic curve

Table 4. Area under the curve (AUC) analysis of feeding frequency among children 6-23 months old, Philippines: 2018-2019

Feeding frequency	*Meeting the recommended energy intake*											
	Energy intake adequacy: ≥50%				*Energy intake adequacy: 75%*				*Energy intake adequacy: 100%*			
	Cut-off	*Sensitivity*	*Specificity*	*AUC*†	*Cut-off*	*Sensitivity*	*Specificity*	*AUC*†	*Cut-off*	*Sensitivity*	*Specificity*	*AUC*†
All children	4.5	0.62	0.55	0.59	4.5	0.73	0.57	0.65	5.5	0.72	0.67	0.69
Breastfed children	3.5	0.60	0.76	0.68	3.5	0.73	0.60	0.67	4.5	0.63	0.77	0.70
6-8 months	-	-	-	-	2.5	0.87	0.56	0.71	3.5	0.70	0.73	0.71
9-23 months	3.5	0.66	0.76	0.71	3.5	0.80	0.56	0.68	4.5	0.68	0.74	0.71
Non-breastfed children	6.5	0.70	0.69	0.69	7.5	0.61	0.74	0.68	7.5	0.69	0.66	0.67

†Area under receiving operating characteristic curve

DDS cut-off points could correctly identify Filipino children with adequate nutrient intake, sensitivity and specificity analyses were done using 50%, 75%, and 100% MPA. Table 3 shows that the DDS cut-offs that maximised sensitivity and specificity increased with MPA, thus improving nutrient intake adequacy. The cut-offs that maximised sensitivity and specificity in correctly identifying breastfed and non-breastfed children with 100% MPA were DDS 5 (AUC=0.58) and 6 (AUC=0.50), respectively.

Association between feeding frequency and energy adequacy

Feeding frequency was positively associated with energy intake as shown in Table 2. Total energy intake and percent energy adequacy increased with feeding frequency: from 462 kcal and 64.2% for two feedings to 840 kcal and 96.0% for ≥6 feedings daily, respectively (p<0.001). The same pattern was also observed in breastfed and non-breastfed children. By feeding frequency recommendations, breastfed children receiving 2-3 feedings daily had a total intake of 463-546 kcal, while non-breastfed children receiving four feedings had an intake of 498 kcal. The percent energy adequacy of breastfed children aged 6-8 months receiving two feedings daily was 71.0%, while those aged 9-23 months receiving three feedings daily had 64.0% energy adequacy. Non-breastfed children meeting the MMF of five had an energy adequacy of 68.0%.

Total intake and energy adequacy were significantly higher among non-breastfed than breastfed children (761 kcal vs. 614 kcal, and 85.2% vs. 75.7%, respectively; p<0.001), while the opposite was observed in terms of feeding frequency. Feeding frequency and total intake were positively, strongly correlated among breastfed children (r_s=0.62; p<0.001) and positively, moderately correlated among non-breastfed children (r_s=0.43; p<0.001). Percent energy adequacy was positively, strongly correlated with feeding

Table 5. Association of minimum acceptable diet to nutritional status of children 6-23 months old, Philippines: 2018-2019

Complementary Feeding Indicators	*n*	*Nutritional status*					
		Underweight		*Stunting*		*Wasting*	
		%	*p-value*†	*%*	*p-value*†	*%*	*p-value*†
All Children							
MAD							
Not meeting	7463	16.8	0.782	27.6	0.037*	6.3	0.036*
Meeting	895	16.9		32.3		4.2	
Breastfed children							
MAD							
Not meeting	3658	21.5	0.596	30.8	0.080	7.5	0.019*
Meeting	627	19.7		34.1		4.7	
Non-breastfed children							
MAD							
Not Meeting	3805	12.5	0.169	24.7	0.866	5.3	0.174
Meeting	268	9.9		27.8		3.1	

MAD: minimum acceptable diet
†*p*-value based on Chi-square test
*Significant at p<0.05

frequency among breastfed children aged 6-8 months (r_s=0.61; p<0.001) and positively, moderately correlated among breastfed children aged 9-23 months (r_s=0.51) and non-breastfed children (r_s=0.49) (p<0.001).

In evaluating the IYCF feeding frequency recommendations, our results showed that a feeding frequency cut-off of 4 (AUC=0.71) and 5 (AUC=0.71) for breastfed children 6-8 and 9-23 months old, respectively, and a cut-off of 8 (AUC=0.67) for non-breastfed children maximised the sensitivity and specificity in identifying Filipino children meeting the 100% REI (Table 4). Moreover, it can be noted that energy intake adequacy improved from low (50%), better (75%), to high (100%) as feeding frequency cut-offs increased.

Association between minimum acceptable diet and anthropometric status

Table 5 shows the association between the MAD and anthropometric status of study children. Stunting was positively associated with MAD in all children, reflecting a higher prevalence among those who met the recommendation (32.3%; p<0.05). Meanwhile, wasting was negatively associated with MAD in all children and breastfed children, showing higher prevalence among children who failed to achieve the MAD (6.3% and 7.5%, respectively; p<0.05). No significant associations were found between MAD and anthropometric status among non-breastfed children.

DISCUSSION

Findings of this study suggested that complementary feeding practices measured using the selected 2021 IYCF indicators were associated with the nutrient and energy adequacy of diets in children 6-23 months old. Sensitivity and specificity analyses showed that the 2021 DDS cut-off of 5 was a good proxy indicator in identifying breastfed Filipino children with adequate nutrient intake, but a DDS cut-off of 6 was more fitting for non-breastfed children. For feeding frequency, a cut-off of 4 for breasted children aged 6-8 months, 5 for breastfed children aged 9-23 months, and 8 for non-breastfed children identified children with adequate energy intake, which were higher than the WHO and UNICEF recommendations. Lastly, the MAD indicator demonstrated a positive association with stunting in all children and a negative association with wasting in all children and breastfed children.

Dietary diversity as an indicator of micronutrient adequacy

The diet of Filipino children mainly consisted of rice, milk and dairy, meat, eggs, fruits and vegetables, with a mean DDS of 3.1. Similar to the findings of Molani-Gol, Kheirouri & Alizadeh (2023), DDS was positively correlated with micronutrient adequacy. The MDD has the highest contribution to dietary adequacy (Khor *et al.*, 2016), hence a useful proxy indicator in predicting dietary quality regardless of breastfeeding status (Moursi *et al.*, 2008). Dietary diversity was positively associated with dietary quality in developing countries as mean nutrient density adequacy increased with DDS, regardless of quantity consumed (Dewey *et al.*, 2006; Working Group on IYCF Indicators, 2006). Thus, it is worth highlighting the significantly higher median MPA in children with DDS ≥5 than DDS <5 in this study, implying that the new DDS cut-off could predict higher micronutrient adequacy. However, there was a low MPA among breastfed children in this study. Giving nutritionally adequate complementary foods will likely fill the nutrient gap of certain key nutrients (Dewey, 2013). On the other

hand, the very weak correlation between DDS and micronutrient adequacy among non-breastfed children could be influenced by low intake of foods from different food groups (Kennedy *et al.*, 2007), breastfeeding status, energy intake (Wright *et al.*, 2015), age, and sex (Rani, Arends & Brouwer, 2010).

Understandably, the selected 2021 IYCF indicators are still lacking in validation studies. This study showed that a DDS cut-off of 5 and 6 can correctly identify breastfed and non-breastfed children with ≥100% MPA respectively, which may indicate that the new DDS cut-off indicator is appropriate for breastfed, but not non-breastfed children. Meanwhile, in previous validation studies, a DDS cut-off of 6 could only identify non-breastfed Filipino children with ≥75% MPA (Kennedy *et al.,* 2007).

Feeding frequency as an indicator of energy adequacy

Feeding frequency that is less than recommended can compromise energy intake, which may cause growth faltering, stunting, and micronutrient deficiencies (WHO, 2021). Our findings concur with other studies wherein feeding frequency reflected energy intakes (Dewey *et al.,* 2006; Islam *et al.,* 2008; Roche *et al.,* 2017; Working Group on IYCF Indicators, 2006). Achieving the MMF increases the probability of meeting energy requirements, particularly in developing countries with low or average breast milk intake (Roba *et al.*, 2016). However, despite the significant correlation between feeding frequency and total intake and adequacy, breastfed children aged 6-8 months and 9-23 months, and non-breastfed children aged 6-23 months were not able to meet 100% adequacy with the minimum feeding frequency recommendations. Feyisa *et al.* (2020) found that even children who met the MMF had inadequate energy intake, which could be due to low energy density, tied with the consumption of food with limited diversity in small quantities.

The best feeding frequency cut-offs that could identify breastfed children aged 6-8 and 9-23 months meeting the 100% REI were 4 and 5, respectively, while for non-breastfed children, the identified cut-off was 8. These cut-offs were twice higher than the established recommendations. This could explain the high proportion of children meeting the minimum feeding frequency, yet only nearly a third were able to achieve adequate energy intake based on the established MMF. Hence, increasing the MMF cut-offs may be able to classify more Filipino children with 100% energy adequacy.

Association of MAD to anthropometric status

The MAD indicator is a composite of MDD and MMF, which are essential for proper growth and development among children. More than a quarter of children were stunted and about one-fifth were underweight. Similar with a study from Indonesia (Ahmad *et al.,* 2018), this study found no significant difference between MAD status and underweight prevalence. Meanwhile, there was a negative association between MAD and wasting in all children and breastfed children, and a positive association with stunting in all children. In Kenya, MAD was a significant predictor of wasting among children (Korir, 2013).

The three selected complementary feeding indicators best reflect a child's recent diet as they only capture current food intake of the previous day, implying that these indicators may not be sensitive to chronic undernutrition, thus, showing more association with wasting than stunting (Saaka *et al.*, 2015). Moreover,

anthropometric status of children may be influenced by the dietary diversity component of MAD (Jones *et al.*, 2014). Poor dietary diversity simultaneously affects MDD and thereafter MAD, thus affecting child growth and development (Roba *et al.*, 2016).

Limitations

Limitations may include one-day recall bias and error of mothers or caregivers during interview for the 24-hour dietary recall. Furthermore, as DDS, MMF, and MAD were only based on the current intake using the 24-hour food recall method, these indicators may not reflect on the status of stunting as this is an outcome of long-term exposure to various risk factors. Despite this, our study is the only local study to date that attempted to validate the three selected 2021 IYCF complementary feeding indicators. This study utilised data from national and population-based survey and outcomes may represent the entire country's situation.

CONCLUSION

The study findings provided evidence that DDS and feeding frequency of the 2021 IYCF complementary feeding indicators are valid indicators of adequate micronutrient and energy intakes for children aged 6-23 months. Despite the practicality of these selected IYCF indicators in reflecting dietary adequacy, they may not capture the entire process related to the nutritional outcomes of infants and young children, particularly stunting. Other factors not covered in the study may have influenced the increased risk of stunting.

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Authors' contributions

Goyena EA, conceived, carried out the study, reviewed and edited the manuscript; Maniego MLV, analysed and interpreted the data; Cristobal AG, interpreted and assisted in the write-up of the manuscript; Goyena EA, Maniego MLV & Cristobal AG read and approved the manuscript.

Conflict of interest

The authors declare that they have no competing interests. The author(s) received no financial support for the research, authorship, and/or publication of this article.

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