RESEARCH ARTICLE

Optimized Nutritional Intakes of Fishers' Children in Coastal Communities in Mabini, Davao de Oro, Philippines

Daena Francesca A. Acosta[1], Jon Marx P. Sarmiento[2,*], Leo Manuel B. Estaña[1], Giovanna Fae R. Oguis[1], Sherelyn A. Evangelio[1], Cleto L. Nañola, Jr.[3], Pedro A. Alviola IV[2]

[1]*Department of Mathematics, Physics and Computer Science, College of Science and Mathematics, University of the Philippines Mindanao, Davao City, 8022 Philippines*
[2]*School of Management, University of the Philippines Mindanao, Davao City, 8022 Philippines*
[3]*Department of Biological Sciences and Environmental Studies, College of Science and Mathematics, University of the Philippines Mindanao, Davao City, 8022 Philippine*

ABSTRACT

In the Philippines, the fishers' children are one of the groups with the highest prevalence of malnutrition. Mabini in Davao De Oro is among the municipalities affected by the high incidence of nutrition inadequacies. The study assessed the dietary intakes of fishers' school-aged children during three seasons: Northeast Monsoon (NEM), summer, and Southwest Monsoon (SWM). A stratified random sampling was used to obtain the 112 fishing household data, and the three-day diet recall approach was utilized in gathering nutrition information of 178 fishers' children during the 2017–2018 period. From the Kruskal Wallis test followed by Dunn's post-hoc test, results showed that the total catch per week, income per week, and the average selling price of fish during the three seasons were significantly different with catch and income levels higher during the NEM followed by SWM and summer. Moreover, the results from the linear programming show that the average nutrient intakes of the children were found to be inadequate compared to the recommended energy and nutrient intakes. This result is more noticeable during the summer season when there are low catch and income levels. The results from the optimal diet plan suggest that the recommended nutrient intakes can be attained by increasing the consumption of locally available fish resources and decreasing the consumption of processed foods. Finally, local interventions such as food fortification, school-based feeding programs, and diet supplementation can increase the nutrient adequacy of children in coastal communities.

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1. INTRODUCTION

Developing countries continue to experience micronutrient deficiency which is one of the major development issues. Nutrient inadequacy among children is commonly observed in developing countries such as Western Africa (Fiorentino et al. 2016), Ethiopia (Gashu et al. 2015), Indonesia (Gibson et al. 2020), Bangladesh (Ahmed et al. 2016), and Sri Lanka (Naotunna et al. 2017). Generally, key nutrients, including vitamins A and C, calcium, zinc, and iron, are deficient among children in developing countries (Yip and Ramakrishnan 2002; Pettifor 2014; Maggini et al. 2010; Akhtar et al. 2013). This is also true in the Philippines as the results from the 2018 Filipino National Nutrition Survey data show that stunting and wasting are prevalent among children and adolescents (Dasco 2019; Vargas 2019). Energy and nutrient intakes of Filipino children and adolescents were inadequate in both macronutrient and micronutrient intakes (Angeles-Agdeppa et al. 2019). Furthermore, coastal communities experience food insecurity and nutrient deficiency (Capanzana et al. 2018; De Guzman et al. 2019). Studies on the social and economic impacts of fishing and other livelihood activities in coastal communities are important to improve the welfare of the fishers and their children (Alva et al. 2016; Hussin and Khoso 2017; Capanzana et al. 2018; De Guzman et al. 2019).

Seasons play a key role in fishing communities; specifically, they drive the fish catch level, income, and food consumption of fishing households. For example, fish consumption in Bangladesh is relatively higher during the latter part of the rainy season from October to December (Belton et al. 2014); however, girls, in particular, are more prone to iron deficiency during the rainy season (Ara et al. 2023). In Ghana, the influence of strong ocean currents during low seasonal catch tends to result in higher levels of malnutrition, as income from catch could not meet the necessary food requirements compared to high seasonal catch (Mensah and Antwi 2002). In the Philippines, fishing households experience higher food insecurity during the southwest monsoon, as strong storms often occur, which leads to less catch (Fabinyi et al. 2017).

Food and nutrition insecurity are pervasive in the Philippines, especially among coastal communities. Capanzana et al. (2018) found that fishers' children have a higher incidence of malnutrition among young and school-aged Filipino children. The regular diet of Filipino households living in coastal areas includes cereals, gleaned seafood, fresh fish, root crops, and fruits and vegetables (De Guzman et al. 2019). Furthermore, De Guzman et al. (2019) reported that meat, eggs, and processed food items, such as canned goods and dried fish, were the least consumed due to higher prices as compared with fresh seafood. Furthermore, while fishing is the primary source of livelihood, households also purchase non-fish commodities to supplement their nutritional requirement (Fabinyi et al. 2017).

In this context, major reasons for optimizing nutritional intakes include shifting trends towards Western diets (Pingali 2007), where increased consumption of processed food among schoolchildren is observed (Ricalde et al. 2018). There is a prevalence of undernutrition, particularly in the municipality of Mabini, which ranks among the most nutritionally depressed in the Davao Region (PSA 2018). Also, access to resources, particularly in marine protected areas, is restricted and may impact food consumption and nutrient intakes, especially during summer (Joquiño et al. 2021) and closed fishing season (Macusi et al. 2022). Despite the importance of having adequate food and nutrient intakes in context-specific environments such as marine protected areas where fishing operations are affected by season (Abesamis and Russ 2010; Villanoy et al. 2011), there is a dearth of literature assessing the nexus of seasonal effects, coastal livelihood and nutrition (Joquiño et al. 2021). Thus, this study analyzed the diet intakes of fishers' school-aged children in a marine protected area in Mabini, Davao de Oro. More specifically, the study aimed to evaluate an optimal diet plan using the Linear Programming (LP) approach as it can generate the best possible solutions, especially with increasing constraints (Babu et al. 2014; Gerdessen and de Vries 2015; Maillot et al. 2009; Ricalde et al. 2018).

2. MATERIALS AND METHODS

2.1 Study site

The study was conducted at the Municipality of Mabini, Davao de Oro, Philippines, located in the southern part of the country (Figure 1). Land and water portions of Mabini surrounding the Davao

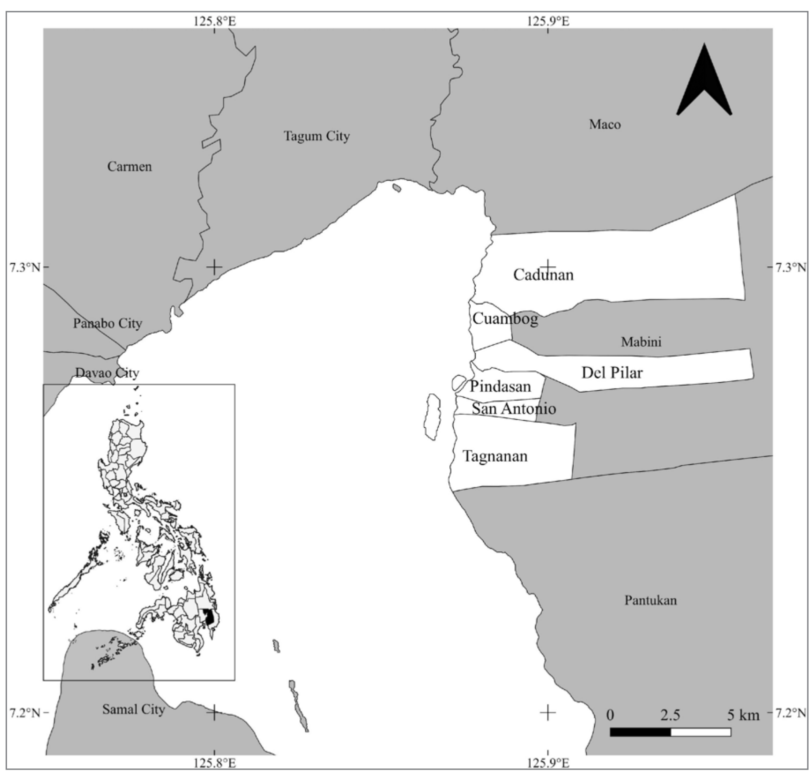

Figure 1. Study site in Mabini, Davao de Oro, Philippines.

Gulf were classified as a protected area with a total area of 6,106 ha under the National Integrated Protected Areas System (NIPAS) or the Republic Act 7586 (Avelino et al. 2019) with coastal villages, namely, Cadunan, Cuambog, Del Pilar, Pindasan, San Antonio, and Tagnanan. The protected area is covered with mangrove forests and abundant coral reefs (Tacio 2013; Cudis 2017). As a marine protected area, regulatory restrictions are implemented, which have direct impacts on fishers' livelihoods (Sarmiento et al. 2021).

Mabini is a coastal community where poverty and malnutrition prevalence are pervasive. Poverty incidence in Davao de Oro during the first semester of 2023 was 14.3% (PSA 2023a), while malnutrition prevalence in Mabini increased from 4.60% in 2016 to 5.09% in 2017 (Philippine Statistics Authority 2018). Fisherfolks in the Philippines are among the poorest in the country, with as high as 30.6% poverty incidence nationally (PSA 2023b). Coastal areas in the Philippines have limited access to marine resources and are affected by the differential effect of seasons on fish catch levels (Abubakar et al. 2012; Abesamis and Russ 2010; Villanoy et al. 2011), which further impacts their food and nutrient intakes (Joquiño et al. 2021).

2.2 Sampling design

In this study, stratified random sampling was employed with villages as strata to determine the number of respondents per village. Using power analysis, a minimum number of 90 samples is needed for having a power of 80% at a significance level of 0.05 for determining an effect size of $d = 0.30$ for one sample group with the assumption using two-tailed *t*-test difference from constant (Cohen 1988; Scholten et al. 1999; Chow et al. 2018; Schunemann et al. 2020). From the master list of the Mabini Municipal Agriculture Office, 112 fishing households were randomly selected as respondents across Northeast Monsoon (NEM), summer, and Southwest Monsoon (SWM). This was broken down as follows: 18 respondents for Cadunan, 31 for Cuambog, 9 for Del Pilar, 19 for Pindasan, 25 for San Antonio, and 10 for Tagnanan. Table 1 presents the total sample of 112 fishing households together with information on 178 school-aged fishers' children across sex and age groups.

Observing the protocol for ethical considerations, the respondents, who are the parents or guardians of the children, were informed of their rights to participate in the survey and were asked to sign a free-prior-informed consent document before commencing the interview. No minors nor senior citizens were respondents to this survey. Moreover, the research team coordinated with the Mabini Municipal Agricultural Office. The survey enumerators were *barangay* nutrition scholars trained in local feeding programs. Prior to the collection of data, the enumerators were oriented for the process of collecting food intake using the three-day diet recall approach. The same instrument was administered across the NEM, summer, and SWM. Surveys were conducted from November to December 2017 for the NEM, from March to April 2018 for summer, and from October to November 2018 for the SWM.

This study considered the age bracket of school-aged children between 6–18 years old. The children were categorized into four different

Table 1. Sampling distribution.

Age groups	Cadunan	Cuambog	Del Pilar	Pindasan	San Antonio	Tagnanan	Total
Number of fishing households	18	31	9	19	25	10	112
Male children							
6–9 years old	8	9	1	4	4	3	29
10–12 years old	8	5	0	2	4	5	24
13–15 years old	5	1	0	4	5	0	15
16–18 years old	1	4	2	3	3	1	14
Female children							
6–9 years old	9	4	3	3	10	5	34
10–12 years old	4	4	2	5	9	1	25
13–15 years old	8	6	2	1	5	1	23
16–18 years old	1	2	2	2	4	3	14
Total	44	35	12	24	44	19	178

age groups based on the 2015 Philippine Dietary Reference Intakes (PDRI). These are (1) 6–9 years old, (2) 10–12 years old, (3) 13–15 years old, and (4) 16–18 years old (FNRI 2015). The questionnaire consists of the demographics of the respondents, the number of fish hours per trip, trips per week, the number of catches per week, the average selling price of fish caught, and the estimated income per week. The three-day diet recall section in the questionnaire consists of the food intakes of fisher's children for breakfast, morning snacks, lunch, afternoon snacks, and dinner within the three-day period. The number of servings and raw materials for the recipes used for each food item were gathered. Compared with the five-day food frequency and 24-hour recall, the three-day diet recall is considered better (Schroder et al. 2001; Yang et al. 2010).

Similar to the approach of Ricalde et al. (2018), the nutrient profiles of the raw materials for all the food items were calculated based on the Philippine Food Composition Table (PhilFCT) (FNRI 2020) and the United States Department of Agriculture Food Composition Database (USDA 2020). The study used the PDRI-recommended energy and 14 nutrients composed of five macronutrients (protein, fat, total carbohydrate, sugar, and dietary fiber), five vitamins (vitamins A and C, riboflavin, niacin, and thiamine), and four minerals (iron, calcium, phosphorus, and sodium). The top 15 food items with the most frequency were chosen as variables (Joquiño et al. 2021). The top 15 food items in this study accounted for the 80th percentile of all the food items in terms of frequency. This procedure is done separately for the NEM, summer, and SWM.

2.3 Data collection

Data were collected from parents and guardians of school children using a pre-tested questionnaire. The English questionnaire was appropriately translated into local dialect (i.e., Cebuano). The data collection protocols followed the ethical principles of the 1975 Helsinki Declaration as revised in 2000 (World Medical Association 2022). Furthermore, the researchers coordinated with the local government unit before conducting the survey and explained the rights of the respondents before obtaining written informed consent from all participants for inclusion in the study. The data was anonymized to protect the integrity and anonymity of the participants. Data was password-protected and stored in secured computer files. Data collection was conducted with the approval of the University of the Philippines Mindanao's Office of Research under both the in-house research project "Identifying important drivers of reef fishery stocks for sustainable management in Mabini, Compostella Valley" and DARE TO (Discovery Applied Research Extension for Trans/ Inter-disciplinary Opportunities) BEAM (Bio Economic Assessment and Modelling) of Reef Fisheries in Davao Gulf for Sustainable Harvest program of the Philippine Commission on Higher Education.

2.4 Linear programming

Linear programming is a tool to find optimal solutions for the linear function of a set of decision variables with respect to multiple linear constraints. It is also assumed that the relationships among the decision variables are linear; that is, none of the decision variables is raised to a power other than 1. Like several economic, industrial, financial, and military systems that can be modeled or approximated by mathematical systems of linear inequalities and equations using linear programming (Dantzig and Thapa 1997), a linear programming approach to optimizing diet problems is also applicable to this study, as was first posed in 1945 by the Nobel Prize-winner George Stigler (1945) and formally solved by George Dantzig (1990). Using linear programming in achieving the ideal diet is a common approach to optimizing diet plans (Babu et al. 2014; Briend et al. 2003; Darmon et al. 2002; Färe and Karagiannis 2014; Okubo et al. 2015). This study follows that of the approach used by Maillot et al. (2009), i.e., the objective of this model is to determine the optimal diet of the participants using the observed diet by minimizing the positive and negative deviations, which are also linear functions of food intakes. The deviational constraint, energy, nutrient, and non-negativity constraints are also linear functions of the decision variables and establish the boundaries of the optimization process. In contrast to the approach of simply minimizing cost to achieve the optimal diet, this approach can satisfy a greater number of nutritional constraints. The linear programming model is denoted as:

Objective function

$$Min\, Y = \sum_{i=1}^{i=F}(P_i + N_i) \qquad [1]$$

Subject to the following constraints:

$$x_i + x_i^{obs}P_i - x_i^{obs}N_i = x_i^{obs} \quad \text{(Deviational Constraint) [2]}$$

$$\sum_{i=1}^{F}(E_i \cdot x_i) \geq E \quad \text{(Energy Constraint) [3]}$$

$$L_j \leq \sum_{i=1}^{F}(B_{i,j} \cdot x_i) \leq U_j \quad \text{(Nutrient Constraint) [4]}$$

$$x_i, P_i, N_i \geq 0 \quad \text{(Non-negativity Constraint) [5]}$$

where Y is the sum of the positive and negative deviations from observed food intakes to the optimal food intakes; i = 1, 2, …, F is the specific food item; F is the total number of observed food items; and P_i and N_i are the positive and negative deviations of the observed and optimal food intakes, respectively.

Furthermore, x_i is the quantity (in grams) of food item i in the optimal diet plan, x_i^{obs} is the mean quantity (in grams) of food item i in the observed food intake pattern; E_i is the amount of energy (in kcal) in 1 g of food item; E is the amount of recommended energy intake based on PDRI; L_j is the recommended lower intake of nutrient j; j = 1, 2, …, 14 are the nutrients; U_j is the tolerable upper intake of nutrient j; B_{ij} is the amount of nutrient j in 1 g of food item i.

A positive deviation of 1, $P_i = 1$, means that the consumption in food item i of the observed diet is 100% higher than in the optimal diet, and a negative deviation of 1, $N_i = 1$, means that the consumption in food item i of the observed diet is 100 % lower than the optimal diet (Gerdessen and de Vries 2015). From all the enlisted food items within the three-day consumption, the top 15 food items from each season were used as the decision variables for the objective function. For the recommended and tolerable intake values, the ideal values for intakes of males and females, as recommended by the PDRI, were used.

The deviational constraints ensure that the objective function retains its linear form. The energy and nutrient constraints are required to ensure that the energy meets the minimum requirement and that its nutrient content is within the bounds of the recommended nutrient intake levels. The usual nonnegativity constraints for the quantity of food items and representing positive and negative deviations from the observed and optimal food intakes also need to be satisfied.

The calculations for the linear program model were generated using Scilab Version 5.5. Moreover, the difference between NEM, summer, and SWM seasons in terms of the number of trips, fishing hours, total catch, income, and selling price were compared using statistical tests. These variables are the major drivers of food consumption and nutrient intakes in fishing communities (Alva et al. 2016; Fabinyi et al. 2017). Since the assumptions of the parametric test pertaining to the homogeneity of variance and normality were not met, the Kruskal-Wallis test, followed by Dunn's posthoc test for non-parametric tests, were performed. Stata Version 15.1 was used for statistical tests.

2.5 Limitations

While the age range of children is from 0 to 18, the data sets used were for school-aged children (i.e., 6–18 years old) since direct interventions are currently focused on reducing malnutrition in school-aged children (Yamaguchi and Takagi 2018). The constraints in the model were limited to 14 key nutrients plus energy, as identified in the PDRI (FNRI 2015).

3. RESULTS

3.1 Socio-demographic profile

The socio-demographic characteristics of the respondents are presented in Table 2. The respondents were composed of 22.32% females and 77.68% males. Married participants were 85.71% of the sample and the remaining 14.29% were unmarried. The majority of the participants were aged 46–59 years old (51.79%) followed by the oldest group composed of 60 years old and above (31.25%). Younger fishers aged 30–45 years old and 18–29 years old were 11.61% and 5.36%, respectively. This suggests that the majority of the fishers were relatively aging. Four-fifths of the fishers had up to high school level education (29.46% high school level, 22.32% elementary graduate, and 25.89% elementary level). The remaining one-fifths were high school graduates (17.86%), college-level (3.57%), and college graduates (0.89%). About half of the sample were members of the organization (49.11%). The average family size was composed of 5–6 members (5.08).

Across seasons, fishing was identified as the primary source of income of the majority of the fishers (91.96% in NEM, 76.79% in summer, and 66.96% in SWM). Most of the fishers had other sources of income, such as laborers with a weekly income of (PHP 1406–1563), massage therapists (PHP 400–1650), public utility vehicle (PUV) drivers (PHP 1500–2000), security guards (PHP 1500), and vendors (PHP 733). Fishers' household members were also engaged in livelihood and employment. The majority were hired as laborers (41% in NEM, 19% in summer, and 36% in SWM), earning a weekly income of PHP 1300–1808. Some were engaged as vendors (24% in NEM, 17% in summer, and 21% in SWM) with weekly earnings of PHP 605–3008. Household members were also participating in fishing activities (9% in NEM, 42% in summer, and 21% in SWM) with an additional income of PHP 400–1575 per week. The rest of the household members had other livelihoods and employment, such

Table 2. Socio-demographic profile of respondents across seasons.

Socio-demographic	Unit	Percent to Total (N=112)	Socio-demographic	Unit	NEM	Summer	SWM
Female	%	22.32	Fishing as main source of income	%	91.96	76.79	66.96
Married	%	85.71	Fisher's weekly income (other work)				
Age			Laborer	PHP	1533	1406	1563
18–29 years old	%	5.36	Massage Therapist	PHP	400	1650	
30–45 years old	%	11.61	PUV Driver	PHP	1500	1500	2000
46–59 years old	%	51.79	Security Guard	PHP		1500	
60 years old and above	%	31.25	Vendor	PHP			733
Education			Household members' weekly income (share of labor participation)				
Below Elementary	%	0.00	Fishing	PHP (%)	400 (9)	1575 (42)	1250 (21)
Elementary Level	%	25.89	Government Worker	PHP (%)	3023 (6)	670 (6)	1318 (12)
Elementary Graduate	%	22.32	Laborer	PHP (%)	1755 (41)	1300 (19)	1808 (36)
High School Level	%	29.46	Laundry	PHP (%)	100 (3)	-	-
High School Graduate	%	17.86	Mechanic	PHP (%)	1800 (3)	-	1200 (3)
College Level	%	3.57	Miner	PHP (%)	2400 (3)	1200 (3)	-
College Graduate	%	0.89	OFW	PHP (%)	4385 (6)	-	5250 (6)
Fishing experience			Security Guard	PHP (%)	1800 (3)	-	-
1–9 years	%	33.04	Tour Guide	PHP (%)	-	1500 (3)	-
10–19 years	%	28.57	Tricycle Driver	PHP (%)	-	2400 (3)	-
20–29 years	%	17.86	Vendor	PHP (%)	605 (24)	1744 (17)	3008 (21)
30–39 years	%	13.39	Volunteer Teacher	PHP (%)	300 (3)	300 (3)	-
40 years and above	%	7.14	Other jobs	PHP (%)	-	2063 (6)	-
Membership to organization	%	49.11					
Average family size	No. of members	5.08					

as government workers, laundry, mechanics, miners, Overseas Filipino Workers (OFWs), security guards, tour guides, tricycle drivers, volunteer teachers, and other jobs.

3.2 Catch and income levels

From a total of 112 respondents, the average catch and income levels were calculated during the three seasons, as shown in Table 3. The Kruskal-Wallis tests showed statistically significant differences in the total catch per week, income per week, and average selling price of fish during the three seasons. Dunn's post-hoc tests showed that the total catch per week was significantly higher during NEM compared to summer and SWM; the income per week was significantly higher during NEM compared to summer but not for SWM; and the average selling price of fish was significantly higher during SWM compared to NEM and summer. However, there were no significant differences in the number of trips per week and the number of fishing hours per trip during the three seasons.

Table 3. Average catch and income levels during three seasons.

	Northeast Monsoon	Summer	Southwest Monsoon	*p*-value
Trips per week (trips/wk)	4.92	4.43	4.63	0.23
Fishing hours per trip (h/wk)	6.03	5.98	5.79	0.65
Total catch per week (kg/wk)	63.11	34.00	38.51	0.02
Income per week (PHP/wk)	4481.57	3260.64	3882.49	0.02
Selling price of fish (PHP/kg)	106.92	109.17	128.59	0.00

Moreover, the selling prices of fish species are presented in Table 4. On average, prices were highest during the SWM season (PHP 129.69/kg), followed by summer (PHP 128.95/kg) and NEM season (PHP 121.25/kg). Among the most expensive fish species are as follows: swordtip squid (PHP 186.67/kg), escochido (PHP 181.46/kg), rainbow runner (PHP 180/kg), golden rabbitfish (PHP 177.78/kg), and Timor/Indian/blacktail emperor red snapper (PHP 176.25/kg). On the other hand, the least expensive fish species are as follows: spotted/yellowing/margined flyingfish (PHP 85/kg), damselfishes (PHP 68.84/kg), Indian anchovy (PHP 60/kg), Bali/white/goldstripe sardinella (PHP 46.44/kg), and Short/island/Indian mackerel (PHP 43.33/kg).

Table 4. Average selling price per fish species across seasons in PHP/kg.

Species	SWM	Summer	NEM	Average
Swordtip squid (nukos)	200.00	185.00	175.00	186.67
Escohido/ eskuhido	-	171.25	191.67	181.46
Rainbow runner (bangkulisan)	-	-	180.00	180.00
Golden rabbitfish (kitong)	183.33	197.50	152.50	177.78
Timor/ Indian/ blacktail/ emperor red snapper (maya-maya)	195.00	-	157.50	176.25
Pinkear/ thumbprint emperor (katambak)	165.00	152.50	190.00	169.17
Sulfur/ deepwater/ cinnabar goatfish (timbungan)	182.19	159.17	155.56	165.64
Indian threadfish/ brassy trevally/jacks (talakitok)	157.50	196.67	134.00	162.72
Striped surgeonfish (indangan)	142.50	217.50	120.00	160.00
Peacock hind/ chocolate/ tomato/ blacktip/ sixbar grouper (lapu-lapu)	-	-	150.00	150.00
Fourfinger/ striped/ smallmouth threadfin (tigi)	150.00	-	-	150.00
Bigeye/ oxeye scad (matambaka)	155.42	147.00	124.70	142.37
Monocle bream (lagaw)	140.00	140.00	-	140.00
Dusky/ whitespot parrotfish (molmol)	146.67	146.67	125.00	139.44
Whitespotted/ doublebar rabbitfish (danggit)	160.39	133.75	119.50	137.88
Goldband/ striped goatfish (salmonete)	148.75	130.00	114.75	131.17
Yellowstripe scad (karabalyas)	134.70	140.00	115.20	129.97
Moonfish (bilong-bilong)	-	127.50	128.33	127.92
Cuttlefish (kubotan)	115.00	-	132.50	123.75
Bullet/ frigate tuna (pirit)	-	135.00	110.00	122.50
Largehead/ Ganges/ Savalai hairtail (diwit)	100.00	170.00	90.00	120.00
Shortfin/ mackerel/ roughear/ redtail scad (moro-moro)	-	120.00	112.50	116.25
Greenback/ lobed river/ Otomebora mullet (banak)	123.33	106.67	112.50	114.17
Agujon needlefish (balo)	110.00	112.67	117.08	113.25
Crescent grunter/ fourline terapon (bugaong)	120.00	100.00	108.89	109.63
Crab (lambay)	110.00	105.00	110.00	108.33
Milkfish (bangus)	-	100.00	-	100.00
Starry/ queen/ masked triggerfish (pakol)	-	-	100.00	100.00
Flathead grey/ longarm/ largescale mullet (gisaw)	120.00	86.67	90.83	99.17
Spotted/ yellowing/ margined flyingfish (bangsi)	80.00	85.00	90.00	85.00
Damselfishes (pata)	68.75	63.34	74.44	68.84
Indian anchovy (bolinao)	50.00	-	70.00	60.00
Bali/ white/ goldstripe sardinella (tamban)	47.42	51.40	40.50	46.44
Short/ island/ Indian mackerel (anduhaw)	50.00	0.00	80.00	43.33
Mixed fish species (unclassified)	145.76	130.31	107.10	127.73
Average	**129.69**	**128.95**	**121.25**	**127.62**

It can be observed that the average selling prices are affected by the types or kinds of fish species across seasons. Relatively lower catch levels are usually associated with high prices and this may have an impact on the income levels of fishers. During summer and SWM, catches are relatively low compared to NEM. However, prices are lowest during the NEM season. Thus, income is affected primarily by the catch levels and is highest during the NEM season compared to summer and SWM.

3.3 Average food intakes

The total catch and income earned by the fishers influenced the kind and amount of food they provided for their household. Hence, the intake of the top food items in the children varies during the three seasons (Table 5). Fish dishes such as fried fish, fish stew *(tinola)*, and vinegar-stewed fish *(paksiw)* were consumed the most during NEM. While rice, powdered milk, boiled egg, and vegetable dishes such as vegetable soup *(law-uy)* and sautéed vegetables *(ginisang gulay)*, were mostly consumed during SWM. The average consumption of these food items was the least during the summer.

Intakes of fish products were higher during NEM, relative to SWM and summer. More portions of fish are set aside for household consumption because of the high volume of total catch during NEM. A high catch rate will result in a high surplus for household consumption. This lowers the average selling price, which will make the fish commodities more affordable (Joquiño et al., 2021). Through increasing revenues and a relatively higher supply of fish, these factors lead to high fish consumption in households. Such changes are still below the PDRI standards (FNRI 2015; Joquiño et al. 2021).

In addition, intakes of vegetable products and other market products were higher during SWM. With a higher selling price of fish during SWM, fishers are encouraged to sell their catch in exchange for buying more food items found in the marketplace. During the summer, however, food intakes were generally lower except for dried fish. The decrease in intake among food items may be attributed to their low amount of income during this season.

3.4 Observed nutrient intakes

During NEM, numerous nutrient intakes were inadequate as compared to the PDRI recommendation (Table 6). Energy intakes were lower across all age groups for females and males. This is also the same for carbohydrates, dietary fiber, calcium, vitamin A, and vitamin C intakes. Inadequate protein and fat intakes also occurred in some age

Table 5. Average food intakes (grams/day) for the top 15 food items.

Food Items	Northeast Monsoon	Summer	Southwest Monsoon
Rice	526.37	498.85	571.64
Fried fish	96.63	80.62	92.98
Fish stew	189.79	133.69	121.25
Powdered milk	15.97	8.34	19.00
Instant coffee	12.78	10.04	12.57
Vegetable soup	74.17	73.57	81.53
Bread	26.54	35.88	56.53
Biscuit	3.21	3.55	6.43
Vinegar-stewed fish	123.81	118.97	79.42
Boiled egg	25.42	27.06	34.80
Dried fish	17.13	24.44	18.54
Sautéed vegetables	44.35	27.67	69.10
Chocolate powdered drink	4.85	0.00	0.00
Fried egg	31.55	25.63	0.00
Instant noodles	33.91	39.54	0.00
Hotdog	0.00	20.35	0.00
Powdered orange juice	0.00	0.00	34.83
Raw banana	0.00	0.00	41.99
Banana cue	0.00	0.00	75.49

Table 6. Observed nutrient intakes of fishers' children according to age and sex during the northeast monsoon.

Nutrients	6 to 9 years old		10 to 12 years old		13 to 15 years old		16 to 18 years old	
	Male	Female	Male	Female	Male	Female	Male	Female
Northeast Monsoon								
Energy (kcal)	1397.31[a]	1363.98[a]	1292.42[a]	1344.35[a]	1189.19[a]	1348.81[a]	1674.61[a]	1602.57[a]
Protein (g)	60.60	57.57[b]	52.76	57.50	49.84[a]	59.54	65.16[a]	64.42
Fat (g)	36.39	37.30	29.87[a]	33.01	28.30[a]	31.96[a]	39.42[a]	37.90[a]
Carbohydrates (g)	206.97[a]	199.62[a]	203.26[a]	204.34[a]	183.84[a]	205.77[a]	264.84[a]	251.07[a]
Dietary Fiber (g)	5.02[a]	5.06[a]	5.46[a]	5.29[a]	4.27[a]	5.01[a]	6.77[a]	6.75[a]
Sugar (g)	21.23	22.55	22.65	24.02	15.56	19.86	24.85	27.09
Calcium (mg)	577.78[a]	534.39[a]	488.48[a]	515.87[a]	448.99[a]	513.64[a]	500.65a	520.62[a]
Phosphorus (mg)	907.18	883.26	793.22[a]	833.98[a]	761.68[a]	854.35[a]	946.85[a]	918.30[a]
Iron (mg)	11.87	11.36	10.22[a]	11.22[a]	9.58[a]	10.63[a]	11.57[a]	12.31[a]
Sodium (mg)	1014.90	1021.32	1001.89	1390.89	1024.96	1558.88	1404.27	1348.37
Vitamin A, RAE (μg)	248.74[a]	216.54[a]	214.24[a]	220.77[a]	192.87[a]	246.05[a]	280.85[a]	267.91[a]
Thiamin (mg)	3.33	4.14	4.26	2.35	3.19	3.14	3.00	4.16
Riboflavin (mg)	0.83	0.86	0.78[a]	0.74[a]	0.65[a]	0.73[a]	0.82[a]	0.87[a]
Niacin (mg NE)	19.04[b]	18.98[b]	17.65	18.42	17.08	19.80	22.55	21.13
Vitamin C (mg)	33.29[a]	30.72[a]	22.59[a]	25.66[a]	17.73[a]	18.33[a]	21.05[a]	28.44[a]

[a] Deficit [b] Surplus

groups. Meanwhile, phosphorus, iron, and riboflavin intakes were insufficient for age groups 10–18. On the other hand, sufficient sugar, sodium, and thiamin intakes were observed for all age groups. There was an observed higher intake of protein for female children ages 6–9 as well as for niacin for females and males of the same age group.

Inadequate nutrient intakes were also observed during the summer (Table 7). Lower intakes across all age groups were evident for energy, dietary fiber, calcium, vitamin A, and vitamin C intakes. Insufficient nutrient intakes also occurred for some age groups. These can be seen for protein, fat, carbohydrates, phosphorus, iron, and riboflavin intakes. In contrast, observed sugar, sodium, and thiamin intakes were within the recommended nutrient range for all age groups. Excess niacin intake was observed for male children ages 6–9, while the rest of the age groups were within the recommended niacin range.

Observed nutrient intakes during SWM were relatively higher in terms of adequacy levels compared

Table 7. Observed nutrient intakes of fishers' children according to age and sex during summer.

Nutrients	6 to 9 years old		10 to 12 years old		13 to 15 years old		16 to 18 years old	
	Male	Female	Male	Female	Male	Female	Male	Female
Summer								
Energy (kcal)	1261.50[a]	1239.40[a]	1205.25[a]	1313.72[a]	1355.57[a]	1246.27[a]	1311.69[a]	1464.47[a]
Protein (g)	49.28	46.99	50.46	49.22	49.90[a]	50.26[a]	53.45[a]	60.07
Fat (g)	28.41	26.90	27.75[a]	27.17[a]	27.04[a]	31.05[a]	23.08[a]	34.40[a]
Carbohydrates (g)	202.23[a]	202.39	188.54[a]	218.13[a]	228.23[a]	192.80[a]	222.56[a]	228.70[a]
Dietary Fiber (g)	5.78[a]	5.72[a]	5.37[a]	6.13[a]	6.83[a]	5.47[a]	6.00[a]	6.45[a]
Sugar (g)	23.55	20.71	20.56	23.82	25.69	15.88	24.05	25.89
Calcium (mg)	430.97[a]	405.88[a]	439.71[a]	420.53[a]	446.79[a]	366.58[a]	369.83[a]	512.86[a]
Phosphorus (mg)	750.20	681.78	759.61[a]	728.01[a]	761.83[a]	705.86[a]	757.26[a]	900.02[a]
Iron (mg)	10.08	10.15	9.55[a]	10.38[a]	10.44[a]	9.34[a]	9.56[a]	12.12[a]
Sodium (mg)	1198.81	1402.45	1217.13	1474.78	1319.27	1431.77	1653.15	1495.85
Vitamin A, RAE (μg)	216.59[a]	220.45[a]	197.39[a]	230.35[a]	232.28[a]	203.34[a]	207.29[a]	261.18[a]

[a] Deficit [b] Surplus

Continuation of Table 7. Observed nutrient intakes of fishers' children according to age and sex during summer.

Nutrients	6 to 9 years old		10 to 12 years old		13 to 15 years old		16 to 18 years old	
	Male	Female	Male	Female	Male	Female	Male	Female
Thiamin (mg)	3.11	2.69	4.09	3.24	3.97	2.73	3.04	3.58
Riboflavin (mg)	0.72	0.64[a]	0.70[a]	0.69[a]	0.73[a]	0.59[a]	0.65[a]	0.82[a]
Niacin (mg NE)	16.02[b]	14.15	16.83	15.75	16.47	16.62	18.53	19.66
Vitamin C (mg)	27.07[a]	21.45[a]	21.38[a]	22.95[a]	24.56[a]	17.13[a]	16.64[a]	30.38[a]

[a] Deficit [b] Surplus

to NEM and summer despite having lower fish catch levels (Table 8). The relatively lower fish supply has led to an increase in selling prices. Therefore, fishing households during this period prefer to sell their fish catch and purchase substitute food items other than fish (Fabinyi et al. 2017). The increase in nutrient intakes was due to higher consumption of non-fish commodities such as carbohydrate-rich foods, vegetables, and protein. Sufficient nutrient intakes were observed in sugar, sodium, and thiamin intakes for all age groups, while excess nutrient intakes were observed in protein and niacin for some children, ages 6–9. On the other hand, dietary fiber, calcium, vitamin A, and vitamin C intakes were found to be less than the required nutrient intakes in all age groups. Insufficient intakes of energy, carbohydrates, phosphorus, and riboflavin were also observed for females and males ages 10–18. Lower intakes were also found in some age groups in males for the protein and fat intakes and in some age groups in both females and males for the iron intake.

From the nutrient intakes of the children across the three seasons, it can be observed that values were higher during the SWM, followed by NEM, and with the lowest intakes during the summer. Increased consumption of vegetable dishes and other food items purchased from the marketplace during SWM contributed to these higher nutrient values. However, some nutrients were consistently inadequate during the three seasons, such as dietary fiber, calcium, and vitamins A and C. The number of nutrients that did not achieve the recommended values set by the PDRI was highest during summer and lowest during SWM. Moreover, the number of nutrients that did not reach the recommended values was higher for older children (i.e., age groups 10–12, 13–15, and 16–18) than the younger children of age group 6–9.

Table 8. Observed nutrient intakes of fishers' children according to age and sex during the southwest monsoon.

Nutrients	6 to 9 years old		10 to 12 years old		13 to 15 years old		16 to 18 years old	
	Male	Female	Male	Female	Male	Female	Male	Female
Southwest Monsoon								
Energy (kcal)	1616.89	1552.73	1584.79[a]	1634.65[a]	1573.52[a]	1702.67[a]	1883.41[a]	1778.48[a]
Protein (g)	60.15	57.76[b]	61.24	58.33	54.60[a]	59.28	71.36	61.70
Fat (g)	37.88	40.82	37.80	37.79	35.96[a]	37.71	41.91[a]	40.64
Carbohydrates (g)	258.77	238.61	249.94[a]	265.24[a]	257.82[a]	281.48[a]	305.09[a]	291.50[a]
Dietary Fiber (g)	7.86[a]	7.54[a]	7.04[a]	8.37[a]	8.24[a]	8.32[a]	9.66[a]	8.56[a]
Sugar (g)	33.67	33.89	31.79	38.61	38.52	38.65	55.20	45.31
Calcium (mg)	570.96[a]	522.43[a]	530.66[a]	512.42[a]	519.90[a]	591.68[a]	622.02[a]	596.63[a]
Phosphorus (mg)	885.56	842.89	889.50[a]	848.36[a]	816.57[a]	920.62[a]	1009.82[a]	938.41[a]
Iron (mg)	13.32	12.42	12.20	12.31[a]	11.81[a]	13.22[a]	14.12	13.90[a]
Sodium (mg)	1280.86	1012.95	1168.53	1537.06	1353.91	1278.46	1914.85	1152.44
Vitamin A, RAE (µg)	272.44[a]	251.62[a]	263.83[a]	266.47[a]	255.17[a]	287.71[a]	340.01[a]	295.47[a]
Thiamin (mg)	2.54	2.80	2.32	1.39	1.75	2.06	3.66	3.62
Riboflavin (mg)	0.84	0.82	0.83[a]	0.76[a]	0.74[a]	0.85[a]	0.96[a]	0.94[a]
Niacin (mg NE)	17.89[b]	17.14[b]	19.06	18.37	17.03	18.45	25.49	19.94
Vitamin C (mg)	42.38[a]	37.85[a]	32.93[a]	33.01[a]	33.34[a]	34.93[a]	30.09[a]	41.92[a]

[a] Deficit [b] Surplus

Furthermore, the observed nutrient intakes across *barangays* were compared using the test of means (i.e., comparing the average individual *i*th nutrient intake per *barangay* to the average *i*th nutrient intake of all *barangays*). From Table 9, it can be observed that two-thirds of the comparisons were statistically significant. This implies a significant variation in children's nutrient intakes across *barangays* and seasons. Thus, this necessitates further focus at a *barangay* level on improving children's diet.

3.5 Optimal diet plans

The average optimal diet plans for males and females across NEM, summer, and SWM seasons are reported in Table 10. This considers the age groups of children from 6–9, 10–12, 13–15, and 16–18 years old. The optimal diet plan shows the list of food items with the corresponding amount of food the children should consume daily. The model satisfies all nutrient constraints except for the iron requirement for females ages 13–18, which is consistent with the result of

Table 9. Test of means of individual child intake per barangay to average nutrient intake.

Nutrients		**Cadunan**			**Cuambog**			**Del Pilar**	
	NEM	**Summer**	**SWM**	**NEM**	**Summer**	**SWM**	**NEM**	**Summer**	**SWM**
Energy (kcal)	0.0011***	0.0000***	0.0000***	0.6478	0.0000***	0.9380	0.2927	0.9687	0.0316**
Protein (g)	0.2071	0.0000***	0.0000***	0.6820	0.4074	0.2108	0.0480 **	0.5210	0.1378
Total Fat (g)	0.0000***	0.0000***	0.0069***	0.8278	0.0002***	0.0389**	0.4697	0.0716*	0.6769
Total Carbohydrate (g)	0.0078***	0.0458**	0.0000***	0.7729	0.0000***	0.1372	0.9444	0.0618*	0.0293**
Dietary Fiber (g)	0.1074	0.0000***	0.0000***	0.7027	0.0000***	0.3689	0.5248	0.2944	0.0099***
Total Sugar (g)	0.9381	0.0000***	0.0000***	0.0101**	0.0000***	0.0000***	0.0030***	0.0180**	0.0000***
Calcium (mg)	0.0744*	0.0000***	0.0000***	0.1982	0.0109**	0.7095	0.8839	0.3271	0.3501
Phosphorus (mg)	0.0979*	0.0000***	0.0000***	0.0004***	0.0005***	0.1572	0.2041	0.5064	0.0544*
Iron (mg)	0.5197	0.0000***	0.0000***	0.0116**	0.0000***	0.6425	0.7263	0.0629*	0.7649
Sodium (mg)	0.1087	0.0572*	0.0000***	0.0000***	0.0000***	0.0993*	0.0081***	0.4191	0.0876*
Total Vitamin A (µg RE)	0.1037	0.0033***	0.2450	0.1121	0.1505	0.0000***	0.1651	0.0000***	0.0450**
Thiamin (mg) / Vit B1	0.6368	0.0000***	0.0000***	0.1057	0.0408**	0.6922	0.1587	0.083*	0.0964*
Riboflavin (mg) / Vit B2	0.9274	0.0001***	0.0000***	0.9019	0.0000***	0.0170**	0.3145	0.8461	0.2472
Niacin (mg NE)	0.5383	0.0000***	0.0000***	0.2778	0.0055***	0.4061	0.1116	0.4441	0.6955
Vitamin C (mg)	0.9678	0.0000***	0.0000***	0.5336	0.9716	0.0001***	0.0020***	0.6265	0.0000***
Nutrients		Tagnanan			San Antonio			Pindasan	
	NEM	Summer	SWM	NEM	Summer	SWM	NEM	Summer	SWM
Energy (kcal)	0.0056***	0.0000***	0.3983	0.0000***	0.0000***	0.0026***	0.0000***	0.0000***	0.0000***
Protein (g)	0.5819	0.0184 **	0.6649	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
Total Fat (g)	0.0004***	0.0000***	0.0019***	0.0000***	0.0000***	0.0171**	0.0035***	0.0000***	0.0000***
Total Carbohydrate (g)	0.1114	0.0002***	0.0432**	0.0000***	0.0004***	0.6324	0.0000***	0.0000***	0.0046***
Dietary Fiber (g)	0.0084***	0.0000***	0.0002***	0.0000***	0.0000***	0.0008***	0.0041***	0.0000***	0.0000***
Total Sugar (g)	0.0000***	0.0000***	0.2826	0.0000***	0.0000***	0.0000***	0.1340	0.0000***	0.0000***
Calcium (mg)	0.0057***	0.0000***	0.6273	0.0002***	0.0000***	0.4081	0.2199	0.0000***	0.0000***
Phosphorus (mg)	0.0006***	0.0000***	0.0569*	0.0000***	0.0000***	0.0003***	0.0003***	0.0000***	0.0000***
Iron (mg)	0.0009***	0.0000***	0.3676	0.0000***	0.0000***	0.1003	0.0053***	0.0000***	0.0000***
Sodium (mg)	0.0004***	0.0004***	0.0117**	0.0000***	0.0000***	0.0000***	0.9302	0.0000***	0.0000***
Total Vitamin A (µg RE)	0.0005***	0.0082***	0.1989	0.0000***	0.0096***	0.0000***	0.0000***	0.0000***	0.4419
Thiamin (mg) / Vit B1	0.2944	0.0618*	0.1988	0.0000***	0.0000***	0.0000***	0.2446	0.0001***	0.0000***
Riboflavin (mg) / Vit B2	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.3894	0.1994	0.0000***	0.0000***
Niacin (mg NE)	0.1298	0.9190	0.0002***	0.0000***	0.0000***	0.0000***	0.0001***	0.0000***	0.0000***
Vitamin C (mg)	0.0045***	0.0000***	0.5896	0.0000***	0.0000***	0.0005***	0.4487	0.0000***	0.0000***

Significant at *10%, **5%, and ***1%.

Table 10. Average optimal diet plans (grams/day) of male and female children during the three seasons.

Food Items	Northeast Monsoon			Summer			Southwest Monsoon		
	Observed	Optimal for Male	Optimal for Female	Observed	Optimal for Male	Optimal for Female	Observed	Optimal for Male	Optimal for Female
Rice	526.67	1140.01	943.33	498.85	1101.03	900.35	571.64	1041.42	967.04
Fried fish	96.63	37.10	0.00	80.62	32.03	4.82	92.98	38.30	0.00
Fish stew	189.79	7.52	84.35	133.69	91.19	33.42	121.25	76.36	86.80
Powdered milk	15.97	52.57	46.29	8.34	55.95	45.42	19.00	52.93	38.61
Instant coffee	12.78	8.90	0.64	10.04	6.46	5.02	12.57	3.14	0.00
Vegetable soup	74.17	577.61	459.82	73.57	614.76	642.13	81.53	329.41	201.79
Vinegar-stewed fish	123.81	78.09	57.21	35.88	9.69	26.12	79.42	39.71	62.90
Boiled egg	25.42	25.42	19.25	27.06	27.06	27.06	34.80	44.21	34.80
Dried fish	17.13	15.44	18.48	24.44	16.13	10.29	18.54	18.57	20.49
Sautéed vegetables	44.35	45.70	177.41	27.67	27.67	27.67	69.10	171.66	327.89

Ricalde et al. (2018). Moreover, according to the PDRI, iron intake could not be met by the usual diet alone for this age group, and there is a need for additional sources of iron-rich foods, iron-fortified foods, or iron supplements to satisfy the needed requirement (FNRI 2015). Hence, the inclusion of locally available iron sources was incorporated into the model, expanding the top 15 food items.

4. DISCUSSION

4.1 Effects of fish catch and market price

From the observed catch and income levels of fishing households, and the observed food and nutrient intakes of the children, the results suggest that having a high catch of fish does not always mean a higher nutrient intake in the case of Mabini. This is evident in the results during NEM and SWM. During NEM, the fishers have an observed increase in catch and income levels. As a result, they have a larger fish consumption compared to the other seasons, but this is still not adequate to meet the nutritional requirement. Alva et al. (2016) found a correlation between children's fish intake and diet diversity, especially for children residing nearest to the marine protected areas because of the increased economic opportunities, including fishing and tourism-based activities. In this study, it was also found that there are sufficient fish intakes among male and female children across age groups, and to some extent, the locally available food resources are enough to meet the nutritional requirement of children except for the iron requirement.

Relative to NEM, decreasing fish catch and income levels were observed in SWM, however, the fishers have an observed increased children's nutrient intake. Due to a low supply of fish from low levels of fish catch, the market price of fish is higher during this season. This encourages the fishers to allocate a higher proportion of the fish harvest for market trade as opposed to household consumption to buy other market food items (Fabinyi et al. 2017). Increased revenues from market trade may likely result in improved access to market food items, thereby increasing nutritional intake (Fabinyi et al. 2017). As found in this study, their market products are mainly carbohydrate-based items, such as rice and banana products, as well as vegetable products.

During the summer, the fishers have the least observed catch and income levels. Similarly, the selling price of fish is low, and the observed nutrient intakes of the children were the lowest compared to NEM and SWM. With the relatively smaller fish catch and the lower market price of fish, consumption of fish and other food items decreased. Thus, nutritional interventions should be intensified during the summer relative to the other seasons.

4.2 Implications of the optimal diet plans

The food item rice, followed by fish dishes, such as fish stew and vinegar-stewed fish, had the greatest amount of ration in the observed food intakes of the children for three seasons. Rice, being the staple food, is also the main source of energy for these children (De Guzman et al. 2019). Fish dishes are the next frequently consumed foods considering that these are fishing households. Increased household consumption from fish catches can contribute to nutritional adequacy, particularly increased micronutrient intake such as iron, zinc, and vitamin A (Kawarazuka and Béné 2011). Moreover, rice, followed by vegetable dishes, had the greatest amount of share in optimal diet plans across the three seasons. Increased consumption of vegetable dishes was also recommended. This may be attributed to the high levels of vitamins and minerals found in vegetables. Thus, increased consumption of vegetables is recommended to prevent micronutrient deficiencies (Fukuta et al. 2008; Jati et al. 2012).

The optimal diet plan recommended a decrease in the consumption of processed foods such as dried fish and instant coffee because they contain fewer minerals and nutrients. On the other hand, increased consumption of fish stew and fish *paksiw* is suggested due to the food items being simmered and accompanied with vegetables compared with fried fish and dried fish, which are high in sodium and fat contents (Rambeloson et al. 2008). Increased intake of nutrient-dense foods or an increase of food fortification for the commonly consumed food items (Mak et al. 2019; Soe et al. 2020) are among the recommendations that can meet the nutritional requirement of children since increasing the amount of intake in the optimal diet plan may result in increased diet cost. Thus, cost-reducing policy initiatives such as food fortification and school-based feeding programs are important in increasing access to nutritious food (Yamaguchi and Takagi 2018), especially in coastal communities. Long-term and sustained nutritional interventions are needed to enhance children's physical development up to adulthood (Bhargava 2016). Furthermore, socio-demographic factors, including household size and the educational level of the parents, also affect the nutritional status of children (Capanzana et al. 2018; Lone et al. 2020).

Moreover, ongoing interventions in Mabini, Davao de Oro were observed to improve children's nutrient intakes. These include the Integrated Management of Acute Malnutrition and the National Dietary Supplementation Program of the Department of Health XI and National Nutrition Council XI (Regional Development Council XI 2022) and the expansion of daycare centers by the private sector (Sunstar 2023). Moreover, improved access to finance through the establishment of the *Negosyo* center may also lead to improvement in income and nutrition (Regional Development Council XI 2022).

Other options, such as improving livelihood opportunities, may result in less dependence on fishing activities, which increases the capacity of fishers' households to access more nutritious food (Alva et al. 2016). Moreover, Aguinaldo and Gomez (2023) reported construction work, farming, business, and tourism-based activities, such as tour guides, as other sources of supplemental income in coastal communities. Fishing households could also be encouraged to consider other livelihood opportunities, such as small-scale agriculture, as a safety net mechanism to compensate for market- and climate-related disruptions in their fishing livelihood (Benítez and Flores-Nava 2019). While these alternative livelihood options are present in coastal communities, community consultation should be paramount to assess the appropriateness of any planned intervention.

5. CONCLUSION

This study found that there is a significant difference between the catch, income, and price levels across three seasons, and as a result, food consumption and nutrient intakes of fishers' children also varied. Most of the nutrient intakes are low across the three seasons, and in particular, the observed nutrient adequacy is lowest during the summer season, which also corresponds to low fish catch and price levels. Moreover, due to the influence of high market prices, there is an increase in cereal and vegetable intakes during SWM, which increases nutrient adequacy levels. The results of the linear programming model suggest that nutritional adequacy can be achieved using locally available resources, mainly by increasing cereal and vegetable consumption.

Direct interventions to improve nutritional adequacy include food fortification programs, school-based feeding programs, and other programs that directly involve household heads in preparing more nutritious food. These measures are cost-effective strategies, especially since increasing nutrient adequacy levels would entail additional costs to the household. Indirect interventions via improving household income, such as increased opportunities for tourism-based livelihood in marine protected areas, can augment household resources, especially during the summer season. Moreover, small-scale agriculture, such as backyard gardening, can be a viable alternative to minimize the negative impact of market- and climate-related shocks on coastal communities.

Furthermore, investigating the relationship between socio-demographic factors and nutritional adequacy would provide information in designing more appropriate program interventions to increase the likelihood of attaining nutritional adequacy.

DATA AVAILABILITY STATEMENT

The data that support this study will be shared upon reasonable request to the corresponding author.

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AUTHORS CONTRIBUTIONS

Acosta DFA: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing-Original draft preparation, Visualization. **Sarmiento JMP**: Methodology, Writing- Original draft preparation, Writing-Review & Editing; Supervision. **Evangelio SA**: Conceptualization, Writing-Review & Editing. **Oguis GFR**: Conceptualization, Writing-Review & Editing. **Nañola CL**: Resources, Writing-Review & Editing, Supervision, Project Administration, Funding Acquisition. **Alviola PA**: Conceptualization, Methodology, Validation, Writing-Original draft preparation, Writing-Review & Editing, Supervision, Project Administration. **Estaña LMB**: Conceptualization, Methodology, Validation, Writing-Original draft preparation, Writing-Review & Editing, Supervision, Project Administration

CONFLICTS OF INTEREST

We declare no conflict of interest.

ETHICS STATEMENT

All the procedures followed were in line with the ethical principles of the responsible committee on human experimentation and the 1975 Helsinki Declaration, as revised in 2000. The authors obtained informed consent from all participants for inclusion in the study.

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