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Predictors of undernutrition among under-five children in geographically isolated and disadvantaged areas in the Philippines

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ABSTRACT

Introduction: Geographically isolated and disadvantaged areas (GIDA) are generally characterised by high morbidity and mortality of children. Undernutrition makes under-five children more vulnerable to disease and death. This study aimed to assess nutritional status and determine factors affecting undernourished children under five in GIDA. **Methods:** The study utilised data from children aged 0-59 months obtained from the 2018-2021 Expanded National Nutrition Survey (ENNS). GIDA were identified and 5,600 children were included in the analysis. Descriptive and multiple logistic regression analyses were employed to investigate associations between nutritional status of children [including stunting, underweight (UW), and wasting] and various factors including child-related, household-related, and biochemical markers. **Results:** Prevalence of UW, stunting, and wasting among children in GIDA were 39.7%, 24.1%, and 6.2%, respectively. Anaemia was of mild public health significance. Multiple logistic analysis revealed significant associations between stunting and vitamin A deficiency (VAD), food insecurity, and unimproved sources of drinking water; underweight and older age, anaemia, VAD, urban residence, and poor wealth; wasting and younger age, being female, and poor wealth. **Conclusion:** Existence of all forms of undernutrition in GIDA intensifies risk of mortality and morbidity among children. This study recommends that government sectors prioritise implementation of nutrition and food supplementation programmes in GIDA where the healthcare system continues to be at a disadvantage. The persistent constraints in GIDA should be addressed to improve food accessibility.

Keywords: children, disadvantaged populations, GIDA, Philippines, undernutrition

INTRODUCTION

In the Philippines, malnutrition remains a problem among under-five children, especially in underserved areas, known in the country as geographically isolated and disadvantaged areas (GIDA). These areas face significant challenges, including limited access to health and nutrition services, as well as high rates of poverty and food insecurity. The Department of Health (DOH) (2020) characterises GIDA by the high morbidity and mortality of children. For instance, infants born in the Bangsamoro Autonomous Region of Muslim Mindanao (BARMM), a region in the southern island of the country, are twice more likely to die in their first five years

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than infants born in the National Capital Region (NCR), the country's capital region. Poverty, armed conflict, war, and the scarcity of available health service facilities and personnel all contribute to the mortality rate in that region (Banaag, Dayrit & Mendoza, 2019), which are all criteria for classifying areas as GIDA (DOH, 2019). Globally, undernutrition is an underlying cause of child mortality due to the higher likelihood of suffering from infectious diseases, diarrhoea, and malaria, along with preterm birth and intrapartum-related complications (Mbuya *et al.,* 2021). These could be prevented with access to skilled delivery at birth, postnatal care, vaccinations, breastfeeding, and adequate nutrition. However, these basic lifesaving interventions are unprocurable in GIDA, resulting in the high deaths of under-five children there.

Undernutrition with sub-forms of underweight (UW), stunting, and wasting makes under-five children more at risk to disease and death (WHO, 2021). Stunting or low height-for-age is the devastating result of poor nutrition in childhood, while wasting or low weight-for-height is the life-threatening result of poor nutrient intake and recurrent illnesses. An underweight or low weight-for-age child may suffer from stunting, wasting, or both. Another form of malnutrition, collectively known as micronutrient deficiency, is caused by a lack of essential vitamins and minerals like iron, folic acid, vitamin A, iodine, and zinc in the diet, which may cause intellectual disability, blindness, or death during childbirth. The key drivers of undernutrition in the Philippines span multiple sectors, underscoring the need for holistic approaches to address this issue (Mbuya *et al.*, 2021). As first outlined in the United Nations Children's Fund (UNICEF) conceptual framework, the determinants of child undernutrition may be immediate, underlying, or basic (UNICEF, 2021). In the Philippines, immediate factors cause undernutrition directly due to inadequate intake or illness (Mbuya, *et al.,* 2021). These immediate factors come from underlying factors that hinder good nutrition, such as inaccessibility to diverse foods, health services, and healthy food environment, as well as inadequate care practices for women. On the other hand, poverty and governance are important basic causes of undernutrition in the country.

The studies that focus on the nutrition and health status of children in GIDA populations in the Philippines remain scarce; the closest literature focused on indigenous peoples (IPs) and considered only UW and stunting (Duante *et al.*, 2022; Viajar *et al.*, 2023). Other studies have reported that undernutrition is prevalent in children belonging to farming and fishing households (Capanzana *et al.*, 2018; de Luna & Talavera, 2021). However, an analysis of these determinants was done for children below ten years old. The factors that were identified to influence undernutrition in these children included lower household wealth index, higher household size, lower dietary diversity score (DDS), unimproved sources of drinking water, and food insecurity. Lower household index and food insecurity in these areas go hand in hand, which worsens nutrition outcomes such as increased risks of UW and stunting. Higher household size also adds to the problem because it means having more people to feed. In poor and food-insecure families, food per capita decreases, as limited food becomes more limited for each family member (de Luna & Talavera, 2021). In turn, dietary intake is compromised leading to poor nutritional status (NS).

The need for more data on nutrition and health information in GIDA is strong. Lack of such data poses challenges for the government to effectively allocate resources to vulnerable populations of children. Therefore, the current study aimed to provide a comprehensive assessment of the current nutrition situation of children in underserved areas, focusing on under-five children in GIDA. By exploring the factors influencing undernutrition, the study may serve as a backbone for local community nutrition assessments. Policymakers and stakeholders can develop effective strategies, programmes, and projects to improve children's health and nutrition.

METHODOLOGY

Data from the 2018, 2019, and 2021 Expanded National Nutrition Survey (ENNS) conducted by the Department of Science and Technology-Food and Nutrition Research Institute (DOST-FNRI) were utilised in this study. Further details of the ENNS methodology have been published elsewhere (DOST-FNRI, 2022). Trained field researchers informed the sampled households and participants about the survey objectives, sampling methods, and procedures.

Out of 42,022 barangays from the Philippine Standard Geographic Code (PSGC), about 6,463 (15.4%) were classified as GIDA. The list was obtained from the open-source website of the Department of Health (DOH), the GIDA InfoSys website (DOH, 2019). From these identified GIDA *barangays,* 1,306 were covered in the ENNS. The total number of households residing in these barangays was 18,121, with 65,506 household members. Only information of 7,083 children aged 0-59 months old was considered in the study. After cleaning the data, 1,483 were excluded due to incomplete information. Only 5,600 children aged 0-59 months old who had complete information for the study variables were included in the analysis (Figure 1).

Study variables

The outcomes of interest for this study included the NS of children – UW, stunting, and wasting. Based on the 2006 WHO Child Growth Standards (CGS) cut-off points (WHO, 2006), a child is considered UW if weight-for-age *z*-score (WAZ) is <-2 standard deviation (*SD*), stunted if height-for-age *z*-score (HAZ) is <-2 *SD*, and wasted if weight-for-length/height z-score is <-2 *SD*.

The independent variables included child, household head, household characteristics, and biochemical markers. Child characteristics included age in months (m) (categorised into 1-0 to 5m, 2-6 to 11m, 3-12 to 23m, 4-24 to 36m, and 5-37 to 59m), sex (male or female), type of residence (rural or urban), wealth index (poor or non-poor), and membership to IPs (yes or no).

The wealth index measures household living standards based on household assets, characteristics, utilities, and infrastructure, including type of dwelling unit, tenure, housing materials, bedrooms, cooking fuel, transport utilities, electricity, and functioning appliances (DOST-FNRI, 2022). IPs are a group of people or societies that live on communally defined territories, share common language, customs, traditions, and cultural traits, and have historically been differentiated from the majority of Filipinos through resistance to colonisation (NCIP, 1998). The Philippines, under the Republic Act No. 8371 or the Indigenous Peoples' Rights Act of 1997, recognises the rights of indigenous cultural communities/indigenous peoples, making it the first country in Asia to officially use the term "indigenous people" and enacting a law recognising their traditional rights (NCIP, n.d.).

Household head characteristics included the household head's working

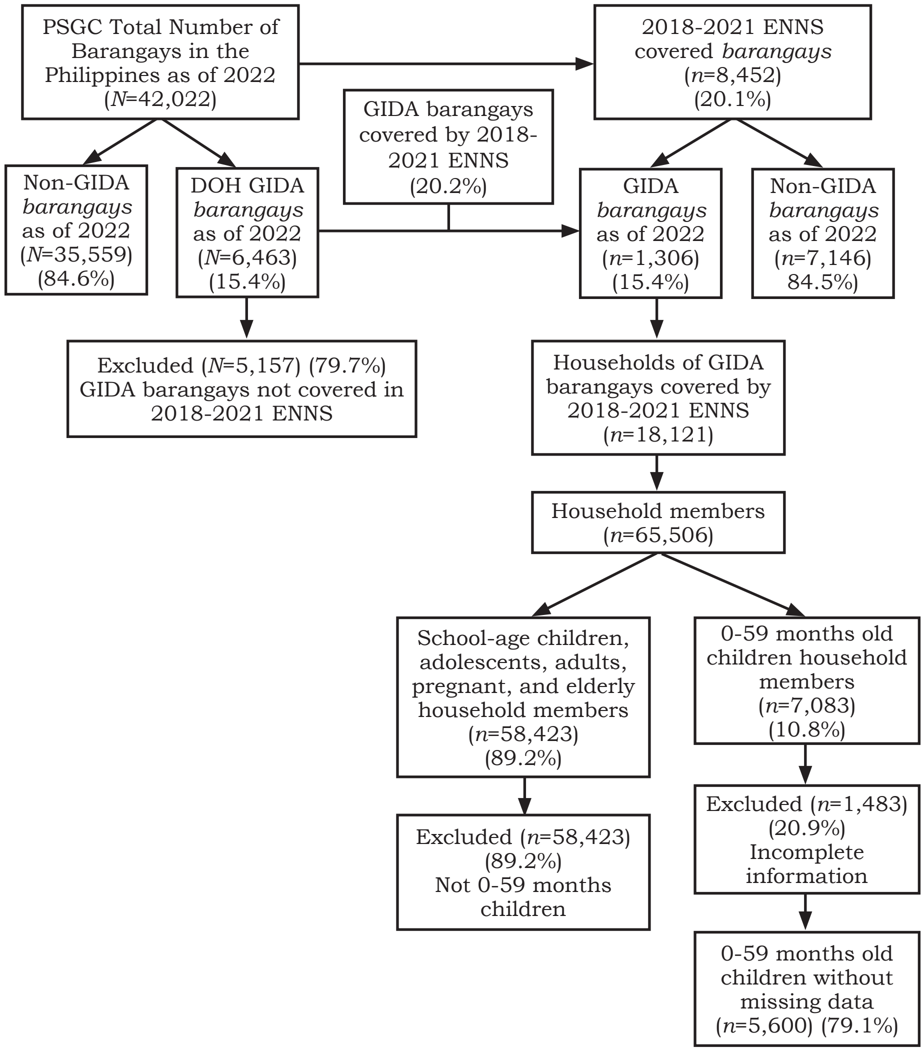

Figure 1. Flow chart of the sample size determination

status (working or not working). Household characteristics included household size (<5 or ≥5), food security status (food secure or insecure) based on the Household Food Insecurity Accessed Scale (HFIAS) assessment tool adapted from the United States Agency for International Development (USAID) Food and Nutrition Technical Assistance (FANTA) Project (Coates, Swindale & Bilinsky, 2007), main waste disposal system (water-sealed, not water-sealed, or no toilet), main water source for drinking, cooking, and hand washing (improved or unimproved source), and recipient (yes or no) of the poverty-reduction *Pantawid Pamilyang Pilipino* Program (4Ps). Biochemical markers included anaemia (anaemic if haemoglobin level <11.0g/dL or not if >11.0g/dL) and vitamin A deficiency (VAD) [low if serum retinol (SR) <19µg/dL, acceptable if 20-49µg/dL, and high if ≥50µg/dL]. Haemoglobin and SR were assessed using the WHO (1972) and WHO/UNICEF/HKI/IVACG (1982) references, respectively. Public health significance of the prevalence of anaemia was classified based on the WHO (2001) Guidelines.

Statistical analysis

Descriptive statistics were calculated for all variables included in the study. Proportions were used for categorical data, while mean estimates with *SDs* and medians with interquartile range (IQR) were analysed for continuous data; 95% confidence intervals were also calculated. The associations between dependent and independent variables were tested using bivariate analysis, which included all relevant socioeconomic, demographic, anthropometric, and biomarker factors that were rationally assumed to have an association with the dependent variable (children's nutritional status). Independent variables with multicollinearity were excluded from the analysis. Variable inflation factors (VIF) were used to detect multicollinearity. A VIF<10 was considered acceptable. Afterward, all independent variables with $p<0.3$ in the bivariate analysis were retained for inclusion in the multiple logistic regression analysis. Multiple logistic regression analysis was employed to identify key determinants associated with the dependent variable. All independent variables that were found to be significant with $p<0.05$ were included in the final model. Adjusted odds ratio (AOR) >1 indicated that undernutrition was more likely to occur, while AOR<1 indicated that undernutrition was less likely to occur.

Statistical analyses, such as means, proportions, and regression analyses, were computed using sampling weights to correspond more closely to the actual distribution of the whole population. All statistical analyses were done using the statistical software package STATA version 16 (StataCorp LLC, Texas, USA). The level of significance was set at $p<0.05$ for all tests that were performed.

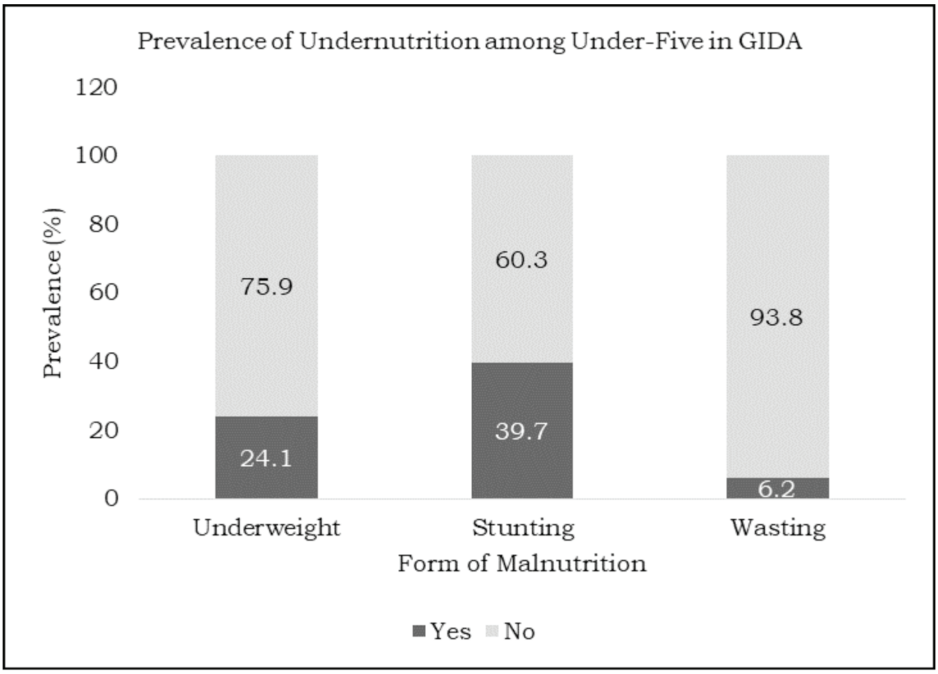

Figure 2. Prevalence of undernutrition among under-five children in GIDA, Philippines

Ethical clearance

The ENNS 2018, 2019, and 2021 were approved by the FNRI Institutional Ethics Review Committee on July 31, 2017, with protocol code FIERC-2017-017. All 2018, 2019, and 2021 ENNS questionnaires were cleared by the Philippines Statistics Authority (PSA) in May 2018, December 2018, and March 2021, respectively. Informed consent forms (ICF) for children under-five were obtained and signed by their parent or guardian before data collection.

RESULTS

Figure 2 shows the nutritional status of under-five children in GIDA. Four in ten (39.7%) children were affected by stunting, two in ten (24.1%) by UW, while 6.2% had wasting status.

Table 1 provides an overview of the independent variables for children in GIDA. More children belonged to the higher age group (24-59 months) than the lower age group (0-23 months). Among the children who had biochemical markers for analysis, the prevalences of anaemia and SR among children aged 6-59 months old in GIDA were also shown. The overall prevalence of anaemic children was 15.8% and was considered a mild public health problem in the Philippines.

As anticipated, the majority of GIDA children resided in rural areas (82.4%). By wealth status, an almost equal distribution of children belonged to the poor (50.9%) and non-poor (49.1%). Moreover, households with five members or more constituted a larger portion (74.4%) than those with <5 members (25.6%). The majority of household heads were employed or owned a business, accounting for 91.5%. A high proportion of GIDA children experienced food insecurity (77.6%). The distribution of health and sanitation practices among GIDA children was included. The majority of GIDA children (76.3%) used water-sealed toilet facilities. Results further showed that most used improved sources of water for drinking (85.5%). In the study, 40.2% of children were recipients of the 4Ps and 26.0% were classified as IPs in GIDA.

The NS of children in GIDA according to their individual and household characteristics are presented in Table 2. Older children exhibited higher proportions of stunting, UW, and wasting. By sex distribution, males had higher proportions of stunting (52.1%), UW (50.7%), and wasting (61.4%) compared to females. In terms of biochemical markers, 18.2% of children with stunting, 21.7% with UW, and 25.0% with wasting were also anaemic, while 30.2% with stunting, 33.8% with UW, and 32.4% with wasting were low or deficient in vitamin A. Higher proportions of rural residents, those with poor wealth status, food insecurity, and a larger household size were present in all forms of malnutrition. On the other hand, the majority of children who were stunted (93.4%), UW (93.5%), and wasted (90.9%) had household heads with jobs or businesses. Most of the children, regardless of NS, had improved sources of drinking water. The distribution of malnutrition was comparable among households receiving 4Ps. Higher proportions of stunted (31.7%) and UW (30.6%) children were considered as IPs.

Results on the analysis of factors associated with undernutrition among under-five children are presented in Table 3. Significant factors that appeared to be associated with stunting among children in GIDA were vitamin A levels, food security status, and main source of drinking water. The likelihood of stunting among children in GIDA was 1.8 times higher for those who had VAD than those who had acceptable SR levels (95% CI: 1.1, 2.8, p=0.024). Children who

Table 1. Distributions of frequency and proportion of child and household characteristics of children in GIDA (*N*=5,600)

Characteristics	*Mean*	*n*	*%*	*95% CI*	
				LL	*UL*
Child characteristics					
Age (mean, months)	32.9	5,600		32.1	33.8
0-5 months		415	7.5	6.4	8.7
6-11 months		467	7.7	6.8	8.6
12-23 months		996	18.0	16.2	19.9
24-36 months		1,127	20.4	18.9	21.9
37-59 months		2,595	46.5	44.2	48.7
Age group with biomarkers					
6-23 months		1,463	27.7	25.3	30.3
24-59 months		3,722	72.3	69.7	74.7
Sex					
Male		2,897	52.0	50.7	53.4
Female		2,703	48.0	46.6	49.3
Anaemia (*n*=832)					
Not anaemic		699	84.2	81.1	86.9
Anaemic		133	15.8	13.1	18.9
Vitamin A (*n*=786)					
Deficient and low		178	22.3	18.9	26.2
Acceptable		599	76.6	72.8	80.0
High		9	1.1	0.4	3.0
Household characteristics					
Place of residence					
Rural		4,838	82.4	77.6	86.3
Urban		762	17.6	13.7	22.4
Wealth status					
Poor		2,704	50.9	48.8	53.1
Non-poor		2,896	49.1	46.9	51.2
Household size (mean)	6.3	5,600		6.1	6.4
<5		1,283	25.6	24.2	27.0
≥5		4,317	74.4	73.0	75.8
Household head's working status					
With job or business		5,128	91.5	90.1	92.7
No occupation		472	8.5	7.3	9.9
Food security status					
Food secure		1,276	22.4	20.2	24.7
Food insecure		4,324	77.6	75.3	79.8
Main waste disposal system					
Water-sealed		4,055	76.3	73.0	79.2
Not water-sealed		830	10.9	9.1	12.9
No toilet		715	12.9	10.6	15.6
Main source of drinking water					
Improved source		4,709	85.5	82.5	88.1
Unimproved source		891	14.5	11.9	17.5
Recipient of *Pantawid Pamilyang Pilipino* Programme (4Ps)					
No		3,313	59.8	58.1	61.5
Yes		2,287	40.2	38.5	41.9
Indigenous people (IPs)					
No		3,496	74.0	71.0	76.8
Yes		2,104	26.0	23.2	29.0

CI: Confidence intervals; LL: Lower limit; UL: Upper limit

Table 2. Proportion of child and household characteristics by nutritional status (*N*=5,600)

Characteristics	n	Stunting				Underweight				Wasting			
		%	95% CI		p-value	%	95% CI		p-value	%	95% CI		p-value
			LL	UL			LL	UL			LL	UL	
All	5,600	39.7	37.2	42.3		24.1	22.8	25.4		6.2	5.4	7.0	
Child characteristics													
Age group													
0-5 months	415	2.3	1.3	4.1	<0.001*	1.5	0.9	2.4	<0.001*	11.0	6.8	17.2	0.011*
6-11 months	467	4.4	3.4	5.6		5.9	4.5	7.7		9.9	6.7	14.4	
12-23 months	996	19.3	16.6	22.3		16.4	13.8	19.5		23.6	19.3	28.5	
24-36 months	1,127	22.6	20.4	24.9		23.3	20.8	25.9		19.9	15.6	25.1	
37-59 months	2,595	51.4	48.5	54.3		52.9	48.9	56.8		35.6	27.7	44.4	
Age group with biomarkers													
6-23 months	1,463	24.3	21.1	27.7	0.003*	22.7	19.5	26.1	0.001*	37.6	32.6	43.0	<0.001*
24-59 months	3,722	75.7	72.3	78.9		77.3	73.9	80.5		62.4	57.0	67.4	
Sex													
Male	2,897	52.1	49.1	55.1	0.942	50.7	46.9	54.5	0.402	61.4	54.8	67.7	0.005*
Female	2,703	47.9	44.9	50.9		49.3	45.5	53.1		38.6	32.3	45.2	
Anaemia (*n*=832)													
Not anaemic	699	81.8	75.5	86.7	0.227	78.3	69.6	85.0	0.041*	75.0	49.5	90.2	0.246
Anaemic	133	18.2	13.3	24.5		21.7	15.0	30.4		25.0	9.8	50.5	
Vitamin A (*n*=786)													
Deficient and low	178	30.2	23.7	37.7	0.010*	33.8	23.7	45.5	0.011*	32.4	17.2	52.5	0.300
Acceptable	599	68.9	61.9	75.1		65.0	53.6	74.9		67.6	47.5	82.8	
High	9	0.9	0.2	3.6		1.2	0.3	4.8		0.0	-	-	
Household characteristics													
Place of residence													
Rural	4,838	84.2	78.7	88.4	0.106	87.5	82.9	91.0	0.001*	86.9	81.7	90.7	0.027*
Urban	762	15.8	11.6	21.3		12.5	9.0	17.1		13.1	9.3	18.3	
Wealth status													
Poor	2,704	60.9	57.6	64.1	<0.001*	62.9	58.3	67.3	<0.001*	60.6	52.0	68.5	0.016*
Non-poor	2,896	39.1	35.9	42.4		37.1	32.7	41.7		39.4	31.5	48.0	
Household size													
<5	1,283	23.5	21.4	25.8	0.018*	22.4	20.0	25.0	0.012*	24.6	17.7	33.3	0.783
>=5	4,317	76.5	74.2	78.6		77.6	75.0	80.0		75.4	66.7	82.3	
Household head's working status													
With job or business	5,128	93.4	90.9	95.3	0.017*	93.5	91.7	95.0	0.013*	90.9	85.9	94.2	0.761
No occupation	472	6.6	4.7	9.1		6.5	5.0	8.3		9.1	5.8	14.1	
Food security status													
Food secure	1,276	18.1	15.5	21.0	0.001*	17.3	13.6	21.8	0.013*	18.9	14.0	25.0	0.231
Food insecure	4,324	81.9	79.0	84.5		82.7	78.2	86.4		81.1	75.0	86.0	
Main waste disposal system													
Water-sealed	4,055	70.5	66.7	74.0	<0.001*	68.1	63.0	72.7	<0.001*	72.4	65.6	78.3	0.369
Not water-sealed	830	12.4	9.9	15.3		12.4	9.4	16.1		11.7	7.0	19.0	
No toilet	715	17.2	14.1	20.7		19.6	15.6	24.3		15.9	10.8	22.7	
Main source of drinking water													
Improved source	4,709	82.0	78.2	85.3	<0.001*	82.1	77.3	86.1	0.017*	78.4	68.7	85.8	0.038*
Unimproved source	891	18.0	14.7	21.8		17.9	13.9	22.7		21.6	14.2	31.3	
Recipient of *Pantawid Pamilyang Pilipino* Programme (4Ps)													
No	3,313	56.4	52.6	60.1	0.028*	55.9	50.9	60.8	0.077	54.3	48.8	59.7	0.052
Yes	2,287	43.6	39.9	47.4		44.1	39.2	49.4		45.7	40.3	51.2	
Indigenous people (IPs)													
No	3,496	68.3	63.6	72.8	<0.001*	69.4	64.6	73.8	0.007*	75.8	68.3	82.0	0.584
Yes	2,104	31.7	27.2	36.4		30.6	26.2	35.4		24.2	18.0	31.7	

CI: Confidence intervals; LL: Lower limit; UL: Upper limit
*Using Wald test of linear hypothesis, $p<0.05$

Table 3. Multiple analysis on the associations between covariates and each anthropometric indicator (n=5,185)

Predictors	Stunting					Underweight					Wasting				
	AOR	*95% CI*		*Wald*	*p-value*	*AOR*	*95% CI*		*Wald*	*p-value*	*AOR*	*95% CI*		*Wald*	*p-value*
		LL	*UL*				*LL*	*UL*				*LL*	*UL*		
Age group															
6-23 months						0.4	0.2	0.7	-3.6	0.003*	1.6	1.3	1.9	5.7	<0.001*
24-59 months						ref					ref				
Sex															
Male											ref				
Female											0.7	0.5	0.9	-3.0	0.009*
Anaemia															
Not anaemic						ref									
Anaemic						2.1	1.2	3.7	2.8	0.014*					
Vitamin A															
Deficient and low	1.8	1.1	2.8	2.5	0.024*	2.1	1.2	3.7	2.8	0.013*					
Acceptable	ref					ref									
High	1.0	0.3	3.5	0.1	0.951	1.4	0.4	5.5	0.6	0.575					
Place of residence															
Rural						ref									
Urban						0.6	0.3	1.0	-2.3	0.036*					
Wealth status															
Poor						1.8	1.1	3.1	2.4	0.029*	1.5	1.1	2.1	2.7	0.017*
Non-Poor						ref					ref				
Food security status															
Food secure	ref														
Food insecure	2.4	1.3	4.6	3.0	0.009*										
Main source of drinking water															
Improved source	0.6	0.3	1.0	-2.2	0.046*										
Unimproved source	ref														

AOR: Adjusted odds ratio; CI: Confidence intervals; LL: Lower limit; UL: Upper limit
*p<0.05

belonged to food-insecure households were 2.4 times (95% CI: 1.3, 4.6, p=0.009) more likely to be stunted than those in food-secure ones. Furthermore, having an improved source of drinking water reduced the risk of being stunted (AOR: 0.6, 95% CI: 0.3, 1.0, p=0.046) among children in GIDA.

Factors of UW that affected children residing in GIDA were age group, anaemia, vitamin A levels, urban residence, and wealth status. Children aged 6 to 23 months old were less likely to be UW than those aged 24 to 59 months (GIDA: AOR: 0.4, 95% CI: 0.2, 0.7). Children who were affected by anaemia were 2.1 times more likely to be UW in GIDA. Children in GIDA with VAD were twice as likely to be UW as those with acceptable SR levels (AOR: 2.1, 95% CI: 1.2, 3.7, p=0.013). Urban dwellers in GIDA were also less likely to be UW than their rural counterparts (AOR: 0.6, 95% CI: 0.3, 1.0, p=0.036). Belonging to the poor wealth status in GIDA (AOR: 1.8, 95% CI: 1.1, 3.1, p=0.029) was also associated with UW.

The significant factors associated with wasting among children in GIDA were age group, wealth status, and sex. There was a higher risk of being wasted if they were under two (2) years old (GIDA: AOR: 1.6, 95% CI: 1.3, 1.9, p<0.001) and classified as poor (AOR: 1.5, 95%CI: 1.1, 2.1, p=0.017). Finally, there were lower chances of being wasted if the child was of the female sex (AOR: 0.7, 95% CI: 0.5, 0.9, p=0.009).

DISCUSSION

This study aimed to fill the gap of limited nutrition and health information among children in GIDA using anthropometric and biochemical data collected from the 2018, 2019, and 2021 ENNS. Results of the study provided a comprehensive view of the prevailing health and nutrition conditions among under-five children in GIDA. They shed light on the associations between undernutrition indicators and various child and household factors of interest within this population group.

The prevalence of stunting (39.7%), UW (24.1%), and wasting (6.2%) were higher than the national prevalences reported by the 2018-2019 ENNS, wherein 29.5% were stunted, 19.0% were UW, and 5.7% were wasted. Stunting in GIDA is considered of "very high" public health significance, with "high" magnitude and severity even higher than the national prevalence. Underweight does not fare better with "high" magnitude and severity, while wasting is of "medium" magnitude and severity (WHO, 1995). These differences in the local and national proportions may mask the severity of the health inequality issue among geographically disadvantaged areas, indicating that current programmes are not reaching the most vulnerable ones. Since GIDA are characterised by high poverty, high food insecurity, and high child mortality and morbidity, stronger and increased monitoring of interventions should be prioritised in GIDA. Doing so may have a direct impact on lowering national undernutrition rates.

Additionally, there was a high prevalence of VAD in GIDA children at 22.3%. Vitamin A supplementation has been an ongoing programme by the DOH, with specific dosages of vitamin A given by mouth to children and mothers alike, depending on their age and risk of developing VAD. However, recent surveys found that children with VAD were less likely to have received their biannual vitamin A supplements and belonged to food-insecure households (Mbuya *et al.*, 2021). Vitamin A supplementation is given on routine schedules and during emergencies by trained rural health care workers either in hospitals, health centres, or during home visits (DOH, 2000). According to Collado (2019), a few of the challenges faced in GIDA include the distance and cost of travel going to the main healthcare centres in which these supplementations take place. These disparities in health and NS highlight the significant differences between GIDA and the rest of the country in terms of undernutrition.

Factors associated with underweight

Factors that affected UW among under-five children in GIDA included anaemia, VAD, urban residence, and wealth status. Children aged 6-23 months had lower odds of UW in this study, similar to an earlier study among children headed by fisherfolks in the Philippines (Capanzana *et al.*, 2018). In this study, 52.9% of UW children were 37-59 months old, compared to 16.4% of UW children who were 12-23 months old. A child's dietary needs increase with age; failure to provide proper nutrition can lead to lower weight-for-age. Additionally, anaemic children were found to have higher odds of being UW. Children in a state of anaemia commonly have iron deficiency caused by factors like poor food absorption, iron-poor diet, or blood loss, which can diminish dietary intake (Mbuya *et al.*, 2021). Anaemia itself causes reduced appetite and frequent infections, both of which can contribute to weight loss. There is a bi-directional relationship between anaemia and undernutrition, which means that the two can influence one another, leading to increased vulnerability among affected children (Adebisi *et al.*, 2019). The presence of VAD among children in GIDA showed twice the increased risk for UW than those with acceptable SR levels. VAD typically results from poor intake of vitamin A-rich foods, leading to anaemia, blindness, and increased risk of mortality. While the link between VAD and UW status is not well established, with previous research pointing VAD to stunting (Viajar *et al.,* 2023), this potential association should be further explored.

Another factor found to be inversely associated with UW was urban residence. Similar to a study in Ethiopia, urban dwelling decreases the risk of UW. Urban areas often have better access to healthcare services, food supply, and improved living conditions compared to rural areas, contributing to better nutrition outcomes (Nigatu *et al.*, 2018). From this, there should be an increased effort to connect rural areas to markets and urban centres (de Luna & Talavera, 2021). The results also indicated that as wealth index improved, the risk of UW decreased, similar to past research studies (dela Luna & Talavera, 2021; Anik *et al.*, 2021). Poor wealth status affects food accessibility, leading to decreased food intake and lower weight. Households that rely on agriculture have higher chances of having UW children because of the economic challenges they face, which prevent them from obtaining essential supplies like food (de Luna & Talavera, 2021). National efforts to increase household income generation for families in GIDA should be strengthened.

Factors associated with stunting

The factors directly associated with stunting in GIDA were food insecurity, VAD, and unimproved sources of drinking water. Children in food-insecure households residing in GIDA were twice more likely to be stunted than food-secure ones. A study in Occidental Mindoro found that the odds of stunting were 23 times higher if the household was food insecure (dela Luna & Bullecer, 2020) and 3.5 times higher in food-insecure households of IP children (Viajar *et al.*, 2023). Economic resources of a family can affect purchasing power, determine dietary diversity, and limit food intake. In GIDA, where more children face food insecurity and live in rural areas with common agricultural and non-wage occupations, limited purchasing power increases the risk of prolonged inadequacy, leading to stunted growth.

VAD was also seen as an independent predictor of stunting among children in GIDA. Ssentongo *et al.* (2020) found that children in Uganda with VAD have 43% higher odds of stunting and 64% higher odds of severe stunting, while no association was found between VAD and UW or wasting. As mentioned earlier, one of the struggles GIDA populations faces is the travel distance when getting supplementations for Vitamin A. Lastly, an improved source of water was found to be protective of stunting in GIDA, similar to the results of related studies (dela Luna & Talavera, 2021; Siddiqa *et al.*, 2023). This is attributed to improved access to sanitation services even in remote areas of the Philippines, as evidenced by the high proportion of children belonging to households with improved sources of water for drinking (85.5%).

Factors associated with wasting

Only age, sex, and wealth status were found to be associated with wasting in GIDA children. Younger children in this study were more likely to be wasted than older children. Wasting is indicated by severe and recent weight loss due to limited food intake or infection (WHO, 2021). Aguayo *et al.* (2017) suggested that it occurs prenatally due to the absence of breastfeeding and improper introduction of complementary food. Early years of child development, which may be affected by wasting, can affect child development as more energy and nutrients are demanded as the child grows older. When these demands are not met, the child continues to be vulnerable to nutritional insufficiency, limiting further weight potential.

Meanwhile, children in GIDA were more likely to be wasted if they were poor and were males. The same result was found by Wali, Agho & Renzaho (2021) wherein children from the poor and poorest quintiles had higher odds of wasting compared to those from wealthier households. Similar to UW, poor wealth status may lead to decreased food intake and poor feeding practices among young children belonging to households that cannot afford quality and nutritious food. Lower-income households tend to spend less on proper nutrition because of already poor living conditions (Wali *et al.*, 2021). Furthermore, results showed that being male was associated with higher chances of being wasted among children in GIDA. In this study, only sex appeared to be a significant factor in wasting, out of all forms of undernutrition. A review of the sex differences in undernutrition showed that in 17 out of 20 studies, boys had higher odds of being wasted than girls (Thurstans *et al.*, 2020). However, another study reported that girls were twice more likely to be wasted than boys (Boah *et al.*, 2019). The variability of results in literature points to the influence of environment and culture, which affects how one gender can be favoured over the other.

This study suggested that the significant predictors of undernutrition among children in GIDA comprised a combination of immediate, underlying, and basic determinants, as outlined in the UNICEF framework mentioned earlier. The primary immediate determinant was VAD, as inadequate vitamin A directly affects the body's ability to function properly and impairs a child's development. The underlying determinants, on the other hand, included food insecurity and unimproved sources of drinking water, both of which were associated only with stunting in this study. This can be attributed to the chronic nature of stunting. Prolonged food insecurity leads to persistent inadequate intake, which then causes stunting. Moreover, unimproved sources of drinking water often led to water-borne gastrointestinal infections, which may exacerbate malnutrition. These are still common in marginalised areas in the country, many of which are in GIDA. Lastly, the basic determinant identified was poor wealth, which was directly associated with being UW and stunted in GIDA. Poor wealth limits household food access to adequate food, healthcare, and even sanitation, contributing to both underlying and immediate determinants.

These findings have important implications for delivering health and nutrition services in GIDA. A previous study on IPs recognised the interdependence of the determinants of undernutrition where those with poor wealth are particularly vulnerable (Viajar *et al.,* 2023). Therefore, persistent socioeconomic disadvantage in GIDA should be treated as a priority. Policy actions and programmes that improve wealth status may improve food security as these two are inextricably linked (de Luna & Talavera, 2021). The Technical Education and Skills Development Authority (TESDA), which launched various programmes in selected GIDA that focused on improving agricultural outcomes, should be expanded and supported by local government units to increase household income generation and eventually improve food security. Improving access to safe drinking water, sanitation, and hygiene (WASH) practices is seen to improve nutrition outcomes; therefore, efforts to reach far-flung areas should be continued. This study also recommends prioritisation of nutrition and food supplementation programmes in GIDA focusing on improving vitamin A status among children. Provision of transport vehicles to and from health centres may be done to encourage participation in routine vitamin A supplementations.

Strengths and limitations

The results of this study demonstrated correlations or associations of UW, stunting, and wasting with various socioeconomic, sociodemographic, and biochemical markers, but do not imply causation. Only variables of interest were included in the analysis of factors; therefore, discussion was limited to those found to be significant. Despite these limitations, the study's strength lay in the large sample size of children in GIDA which provided a valuable source of information that bridged existing gaps in knowledge about this population.

CONCLUSION

In this study, the associations between undernutrition indicators, such as stunting, UW, and wasting, of under-five children residing in GIDA were analysed. The study depicted a higher prevalence of undernutrition among children in GIDA than the 2018-2019 Philippine national prevalence. The alarming prevalence of hidden hunger, particularly anaemia and VAD, was also noted among GIDA children. Multiple logistic regression revealed that among children, younger age decreased the odds of UW, but increased the odds of wasting. Anaemia was only associated with UW. Poor wealth status increased the likelihood of UW and wasting. Food insecurity affected stunting twice as much in GIDA children. The presence of VAD also increased the odds of UW and stunting. Finally, living in urban areas, having an improved source of water, and being female were protective of UW, stunting, and wasting, respectively.

The existence of undernutrition in GIDA intensifies the risk of mortality and morbidity among children. Besides the geographic disadvantage of children in these areas, socioeconomic constraints exacerbate the importance of disaggregated data for proper targeting of government policies and localised interventions. Aside from strengthening the healthcare systems in each GIDA, it is imperative to guarantee the sustainability of healthcare resources through regular monitoring and evaluation. Further research studies on the dietary and health practices of parents in GIDA particularly infant and young child feeding practices (IYCF) and its association with undernutrition outcomes should be explored.

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Authors' contributions

Maniego MLV, principal investigator, conceptualised, designed and supervised the implementation, drafted the manuscript, and approved the final manuscript; Duante CA, assisted in the drafting of the manuscript and reviewed the manuscript; Velasquez MBM, conducted data analysis under guidance of the primary author, assisted in the drafting of the manuscript, and reviewed the manuscript; Tordecilla RL, contributed significant technical assistance in data interpretation, drafted the manuscript, and reviewed the manuscript.

Conflict of interest

The authors declare no potential conflicts of interest concerning the study, authorship, and/or publication of this article.

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