Journal of Epidemiology and Public Health (2025), 10(04): 477-489
Masters Program in Public Health, Universitas Sebelas Maret

Research
Open Access

The Relationship Between Macronutrient Intake and Stunting Among Children Aged 1–2 Years: Quantitative and Qualitative Approaches

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Received: 19 June 2025; Accepted: 16 July 2025; Available online: 16 October 2025

ABSTRACT

Background: Stunting among children aged 1–2 years remains a critical public health concern in Indonesia, particularly during the vital 1,000-day window of child development. This study aimed to analyze the relationship between macronutrient intake and stunting using a mixed-methods approach.
Subjects and Method: This was a sequential explanatory mixed-methods study conducted from February 2024 to May 2025 at Community Health Center Dadok Tunggul Hitam, Padang City. The quantitative component employed a case-control design involving 66 children aged 1–2 years, divided equally into stunted (cases) and non-stunted (controls) groups. Sampling was conducted purposively for cases and by simple matching for controls. The independent variables were intake of carbohydrates, proteins, and fats; the dependent variable was stunting, defined using WHO growth standards. Macronutrient intake was assessed via a 24-hour recall. Data were analyzed using Chi-square tests to determine associations, and Odds Ratios (OR) with 95% Confidence Intervals (CI) were reported. The qualitative phase included interviews with mothers, health workers, and community volunteers, analyzed thematically using NVivo 12.
Results: Children with inadequate carbohydrate intake were significantly more likely to be stunted (OR=3.50; 95% CI=1.27 to 9.64; p=0.015). No statistically significant associations were found for protein intake (OR=2.60; 95% CI=0.91 to 7.44; p=0.074) or fat intake (OR=2.44; 95% CI=0.89 to 6.70; p=0.082). Qualitative findings revealed barriers such as loss of appetite during illness, preference for snacks, food aversions, and limited maternal knowledge and resources, all of which contributed to inadequate macronutrient intake.
Conclusion: Inadequate carbohydrate intake was significantly associated with stunting in children aged 1–2 years. Contextual factors such as eating behavior and parental feeding practices further influenced nutritional outcomes. Interventions should address both dietary intake and behavioral barriers within families.

Keywords: Stunting, Macronutrient intake, Carbohydrates, Toddler nutrition, Case-control, Mixed-methods

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Cite this as:
Nesva IS, Sulastri D, Basyir V (2025). The Relationship Between Macronutrient Intake and Stunting Among Children Aged 1–2 Years: Quantitative and Qualitative Approaches. J Epidemiol Public Health. 10 (04): 477-489. https://doi.org/10.26911/jepublichealth.2025.10.04.04.

BACKGROUND

Stunting is a condition in which a child's height-for-age is below -2 standard deviations based on WHO growth standards, typically resulting from chronic undernutrition and/or recurrent infections (WHO, 2020). This condition can lead to long-term impacts on cognitive development, productivity, and overall health (Purwandini and Atmaka, 2023).

In Indonesia, the prevalence of stunting decreased slightly from 24.4% in 2021 to 21.6% in 2022, with a national target of 14% by 2024 (Kemenkes, 2023; Kemenkes, 2024). However, progress remains slow. In West Sumatra, stunting rose to 25.2% in 2022 before slightly declining to 23.6% in 2023. Padang City recorded 1,268 stunted children in 2023, and Community Health Center Dadok Tunggul Hitam had the highest number of cases among all local health centers, including 33 stunted toddlers from January to August 2024.

Stunting often stems from inadequate nutrition during the critical 1,000-day window—from pregnancy to a child's second birthday—compounded by socioeconomic factors like poverty, low maternal education, and limited access to healthcare and nutritious food (Hasriani, 2023). Although many studies focus on micronutrients or environmental aspects, fewer have explored how macronutrient intake—carbohydrates, proteins, and fats—specifically contributes to stunting (Ayuningtyas et al., 2018).

Macronutrients are essential for child growth: carbohydrates provide energy, protein supports tissue building and linear growth, and fat aids in brain development and vitamin absorption. Both deficiencies and imbalances, such as high carbohydrate but low protein or fat intake, can hinder optimal growth (Yuliantini et al., 2022; Diniyyah and Nindya, 2017). These dietary patterns are often influenced by economic constraints and cultural habits that favor inexpensive, filling foods over nutritionally balanced meals (Amalia et al., 2023).

The 1–2 year age range is a vital phase within the 1,000-day period, where failure to meet nutritional needs can lead to irreversible growth and cognitive delays (Sasube and Luntungan, 2017). Given the high number of stunting cases in Community Health Center Dadok Tunggul Hitam, this study aimed to analyze the relationship between macronutrient intake and stunting among children aged 1–2 years using both quantitative and qualitative approaches. The mixed-methods design allows for objective measurement of dietary intake and stunting outcomes, while also exploring parental feeding practices and the barriers they face in providing adequate nutrition.

SUBJECTS AND METHOD

1. Study Design

This study employed a mixed-methods approach using a sequential explanatory design. The research began with a quantitative case-control study to assess the relationship between macronutrient intake (carbohydrates, proteins, and fats) and stunting in children aged 1–2 years. The qualitative phase was followed to explore in depth the contextual factors influencing child feeding practices. The study was conducted in the working area of Community Health Center Dadok Tunggul Hitam, Padang City, from February 2024 to May 2025.

2. Population and Sample

The target population consisted of children aged 1–2 years in the Community Health Center Dadok Tunggul Hitam area. The sample included 66 children: 33 stunted (case group) and 33 non-stunted (control group), selected using purposive sampling for cases and simple matching for controls (based on age and sex). Inclusion criteria

were children aged 1–2 years with complete data and whose mothers consented to participate. Exclusion criteria included children with congenital abnormalities or incomplete data after three follow-up visits.

In the qualitative phase, participants included 1 key informant (nutrition program officer), 5 mothers of stunted children, 2 community health volunteers (Posyandu cadres). Informants were selected purposively until data saturation was reached.

3. Study Variables

The dependent variable in this study was stunting. Independent variables were macronutrient intake (carbohydrates, proteins, and fats), energy intake, exclusive breastfeeding, maternal education, employment status, family income, child sex, weight, and birth weight.

4. Operational Definition of Variables

Carbohydrate Intake: The amount of carbohydrate (grams/day) consumed by the child within the past 24 hours, assessed using a structured 24-hour dietary recall and compared to the Recommended Dietary Allowance (RDA) for Indonesian toddlers aged 1–3 years (215 grams/day).

Protein Intake: The amount of protein (grams/day) consumed by the child as reported by the caregiver using a 24-hour dietary recall and compared to the RDA for toddlers aged 1–3 years (20 grams/day).

Fat Intake: The total fat (grams/day) intake measured via 24-hour recall and compared with the RDA for toddlers aged 1–3 years (45 grams/day).

Stunting: was defined using WHO growth standards (Z-score < -2 SD). All variables were measured using validated instruments and recorded on nominal or ordinal scales, as appropriate.

5. Study Instrument

Quantitative data were collected using a 24-hour food recall form to assess macronutrient and energy intake. Anthropometric measurements (height using microtoise) based on WHO standards. Qualitative data were collected using in-depth interview guides, audio recorders, field notes, cameras, and observation checklists.).

6. Data Analysis

Quantitative data analysis involved univariate analysis to describe the distribution of each variable. Bivariate analysis using Chi-square tests to assess associations between macronutrient intake and stunting. Qualitative data were analyzed using the Creswell method, including coding and thematic analysis supported by NVivo 12 software. Data validity was ensured through credibility checks such as triangulation, member checking, and audit trails.

7. Research Ethics

This study obtained ethical approval from the Research Ethics Committee of Universitas Andalas. All participants received informed consent, and data confidentiality was strictly maintained throughout the study with number 2.661/XI/HREC/2024.

RESULTS

1. Sample Characteristics

A total of 66 children aged 1–2 years participated in the study, consisting of 33 children in the stunting group (cases) and 33 children in the non-stunting group (controls).

Table 1. Frequency distribution of children characteristics in the working area of Community Health Center Dadok Tunggul Hitam, Padang

Characteristics	Category	Case (n=33)		Control (n=33)		Total (n=66)	
		n	%	n	%	n	%
Child's Sex	Male	16	48.5	17	51.5	33	50
	Female	17	51.5	16	48.5	33	50

Characteristics	Category	Case (n=33)		Control (n=33)		Total (n=66)	
		n	%	n	%	n	%
Received Exclusive Breastfeeding	Yes	22	66.7	19	57.6	41	62.1
	No	11	33.3	14	42.4	25	37.9
Height (cm)	< 92	33	100	33	100	66	100
	≥ 92	0	0	0	0	0	0
Weight (kg)	< 13	33	100	33	100	66	100
	≥ 13	0	0	0	0	0	0
Birth Weight (grams)	< 2500	9	27.3	2	6.1	11	16.7
	≥ 2500	24	72.7	31	93.9	55	83.3
Energy Intake (kcal/day)	< 1350	14	42.4	11	33.3	25	37.9
	≥ 1350	19	57.6	22	66.7	41	62.1
Family Income	< Rp. 2,811,449	13	39.4	11	33.3	24	36.4
	≥ Rp. 2,811,449	20	60.6	22	66.7	42	63.6
Mother's Education Level	Low	23	69.7	19	57.6	42	63.6
	High	10	30.3	14	42.4	24	36.4
Mother's Employment Status	Employed	5	15.2	9	27.3	14	21.2
	Unemployed	28	84.8	24	72.7	52	78.8
Protein Intake	Poor	15	45.5	8	24.2	23	34.8
	Good	18	54.5	25	75.8	43	65.2
Fat Intake	Poor	17	51.5	10	30.3	27	41
	Good	16	48.5	23	69.7	39	59
Carbohydrate Intake	Poor	22	66.7	12	36.4	34	51.5
	Good	11	33.3	21	63.6	32	48.5

Table 1 shows the frequency distribution of toddler characteristics in the working area of Community Health Center Dadok Tunggul Hitam, Padang. The sex distribution of children was nearly balanced, with male children accounting for 48.5% in the case group and 51.5% in the control group, and female children comprising 51.5% and 48.5% in the respective groups. All children in both groups had a height of less than 92 cm (100%) and a weight of less than 13 kg (100%). Most children were born with normal birth weight, particularly in the control group (93.9%) compared to the case group (72.7%). Regarding energy intake, a higher proportion of children in the control group met the daily intake of ≥1350 kcal (66.7%) compared to the case group (57.6%). Interestingly, the proportion of children who received exclusive breastfeeding was higher in the case group (66.7%) than in the control group (57.6%).

The majority of families in the study had an income above the regional minimum wage, with 60.6% in the case group and 66.7% in the control group. Regarding maternal education, most mothers had a low education level 69.7% in the case group and 57.6% in the control group. Additionally, the majority of mothers in both groups were not employed, with a higher proportion in the case group (84.8%) compared to the control group (72.7%).

Among children with inadequate protein intake, 45.5% were found in the stunting group (cases), compared to 24.2% in the non-stunting group (controls). Conversely, adequate protein intake was more common in the control group (75.8%) than in the case group (54.5%). Regarding fat intake, 51.5% of children with inadequate fat intake were in the case group, compared to 30.3% in the control group. In contrast, 69.7% of those with adequate fat intake were in the control group, while only 48.5% were in the case group. Carbohydrate intake showed a more pronounced difference, with 66.7% of children with inadequate carbohy-

drate intake found in the case group, compared to 36.4% in the control group. Conversely, 63.6% of children with adequate carbohydrate intake were in the control group, while only 33.3% were in the case group.

Table 2. Distribution macronutrient intake in the working area of Community Health Center Dadok Tunggul Hitam, Padang

Macronutrient (g/day)	Case (n=33)				Control (n=33)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Carbohydrate	163.18	71.06	71	494	186.9	58.12	125	384
Protein	31.93	16.94	15	60	45.87	18.12	14	65
Fat	47.63	25.94	8	111	48.86	11.08	20	69

Table 2 presents the mean macronutrient intake of childrens. The mean carbohydrate intake in the case group was 163.18 grams/day, while the control group had a higher mean intake of 186.90 grams/day. The mean protein intake was 31.93 grams/day in the case group, compared to 45.87 grams/day in the control group. The mean fat intake in the case group was 47.63 grams/day, slightly lower than the control group, which averaged 48.86 grams/day.

2. Bivariate Analysis

Bivariate analysis was conducted to evaluate the association between macronutrient intake (energy, protein, fat, and carbohydrates) and the incidence of stunting. Table 3 shows Bivariate analysis of the macronutrient intake and Stunting.

Table 3. Bivariate analysis of the macronutrient intake in the working area of Community Health Center Dadok Tunggul Hitam, Padang

Macronutrient	Case (n=33)		Control (n=33)		OR	95%CI		p
	n	%	n	%		Lower Limit	Upper Limit	
Protein Intake								
Poor	15	45.5	8	24.2	2.60	0.91	7.44	0.074
Good	18	54.5	25	75.8				
Fat Intake								
Poor	17	51.5	10	30.3	2.44	0.89	6.70	0.082
Good	16	48.5	23	69.7				
Carbohydrate Intake								
Poor	22	66.7	12	36.4	3.50	1.27	9.64	0.015
Good	11	33.3	21	63.6				

As shown in Table 3, inadequate protein intake was more commonly found in the case group (45.5%) compared to the control group (24.2%). The bivariate test yielded a p-value of 0.074, indicating that there was no statistically significant association between protein intake and stunting. Table 3 also shows inadequate fat intake was more frequent in the case group (51.5%) than in the control group (30.3%). The chi-square test showed a p-value of 0.082, indicating no statistically significant association between fat intake and stunting. higher proportion of children in the case group (66.7%) had inadequate carbohydrate intake, compared to 36.4% in the control group. The chi-square test showed a p-value of 0.015, indicating a statistically significant association between carbohydrate intake and stunting. The odds ratio of 3.50 suggests that children with inadequate carbohydrate intake were 3.5 times more likely to be stunted than those with adequate intake.

3. Qualitative Analysis

The qualitative approach aimed to explore in greater depth the barriers, attitudes,

maternal practices, and knowledge related to macronutrient intake. The qualitative data were collected through in-depth interviews. A total of eight informants participated in the interviews, including five parents of stunted children, two community health volunteers (Posyandu cadres), and one healthcare worker in the working area of Puskesmas Dadok Tunggul Hitam, Padang. Researchers used the Nvivo 12 tool to analyze the data, which resulted in 2 themes, 4 categories and 10 codes, as illustrated below. The results of this qualitative study are discussed in 2 themes, namely patterns of barriers that affect macronutrient intake and recommendations for macronutrient nutrition interventions.

The study identified several barriers to adequate macronutrient intake in children, categorized into factors such as eating difficulties during illness, preference for snacks, and aversion to certain types of food. These factors directly affect dietary patterns and the adequacy of children's macronutrient intake. Interview findings revealed that the main categories of barriers included reduced appetite during illness, food rejection after consuming snacks, dislike of soft-textured foods, and a stronger preference for snacks over main meals. Nearly all informants reported that their children experienced difficulty eating when they were ill. This is reflected in the following quotes:

"...When they're sick, they don't want to eat; when they're not sick, it's okay..."

Although parents attempted to provide food, the children's poor health condition often led to a significant loss of appetite, resulting in inadequate macronutrient intake. Children also tended to reject main meals after consuming sugary snacks.

"...If they've eaten too much sugar, they won't eat anymore..."

This behavior indicated a stronger preference for sweet or snack-type foods over more nutritious main meals. Some children showed a dislike for soft-textured foods such as porridge or mashed items.

"...They don't want porridge or anything like that..."

Aversion to certain textures required parents to modify how they presented food in order to make it more acceptable to their children. In several cases, children were more inclined to choose snacks over main meals.

"...If they eat too many cakes, they don't want to eat a proper meal..." (IFN 3).

Such preferences hinder the fulfillment of nutritional needs, especially protein and vegetables, which are typically consumed less compared to carbohydrate-dense snacks.

Interview results showed that most mothers had received nutrition education on macronutrients, particularly protein, through Posyandu activities, community nutrition centers, or interactions with health workers. This information encouraged several mothers to improve their children's diets by offering protein-rich foods such as chicken, fish, eggs, tofu, and tempeh.

"...Yes, I learned about rice, eggs—that was explained by the health staff..."

"...He likes chicken. Though he doesn't like eggs, he'll eat them as egg rolls..."

"...There's still some leftover chicken, fish, potatoes, eggs, and carrots... Sometimes it's just eggs without vegetables..."

These statements reflect maternal efforts to diversify meals. However, despite improvements in protein intake, other macronutrients like fat were often overlooked.

"...Sometimes it's irregular. If he eats cake in the morning, he won't want rice later..."

This suggests that mothers often replaced main meals with snacks. IFN4 also noted that fruits were rarely given, as the household prioritized buying side dishes.

Despite increased awareness of the importance of protein, nutritional balance was still lacking. This is further illustrated by the following quote.

"...I thought just eating rice was enough, whatever the side dish is, as long as he's full..."

Most mothers also reported difficulties in managing their child's eating behavior, especially when the child refused certain foods.

"...Some moms say the child won't eat at all. We already gave them food, but they refuse. They don't want fish. So, we keep educating them on how much is needed, but many still complain their child won't eat. Most kids are hard to feed anyway..."

These challenges made it difficult for mothers to ensure adequate macronutrient intake for their children.

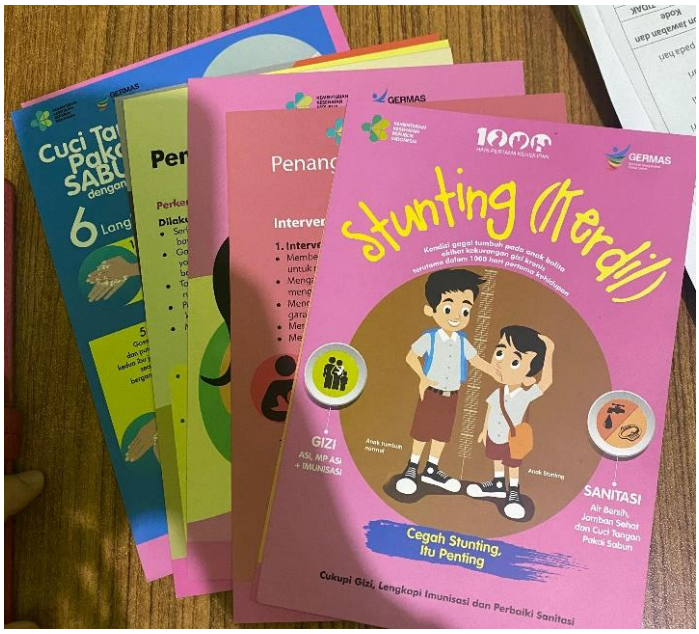

Figure 1. Nutrition Education Leaflet in the Working Area of Community Health Center Dadok Tunggul Hitam, Padang

Observations indicated that nutrition education at community health center commonly utilized a leaflet (Figure 1), which allowed mothers to directly ask health workers questions. However, the availability of these materials was limited—each community health center typically had only one leaflet, shared among attendees. This limitation was attributed to budget constraints that hindered mass printing. The restricted availability of printed educational materials supports the interview findings, indicating that maternal understanding of nutrition is not only influenced by knowledge but also by limited access to information. Therefore, more effective and sustainable educational strategies are needed, including broader distribution of materials to reach a wider audience of mothers attending integrated health service post.

Based on qualitative findings, researchers identified two main themes for macronutrient intervention among families with children aged 1–2 years. Most informants emphasized that children often become bored with repetitive meals and that variation is key to maintaining appetite.

"...Sometimes they get bored with the same food, so we give them different kinds..."

Parents also noted that food texture matters; children were more likely to reject hard foods

"...If the food is hard, he won't eat it—it needs to be mashed..."

Regarding parental education, many informants highlighted the importance of delivering information in a way that is simple, clear, and reinforced over time.

"...Some parents understand, some don't. Sometimes they ask questions, but if you ask them again later, they forget what was explained..."

Health workers also pointed out that outreach is only effective when parents attend the sessions.

"...Education is effective only if the mother comes—otherwise, the information doesn't reach them..."

Despite exposure to health promotion about nutrition and stunting, many mothers admitted they did not retain the information.

"...Yes, I remember something about food and hygiene, but I've forgotten now..."

"...Yes, but I don't remember anymore..."

These findings suggest that for interventions to be successful, they must be practical, continuous, and delivered in a way that supports both comprehension and retention among parents.

Community-based programs were highlighted as essential, particularly through strengthening Posyandu and community nutrition houses (Rumah Gizi), in response to practical barriers such as parental absence due to work obligations:

"...Sometimes the parents are working, so only the father is at home, and he doesn't bring the child. Most parents are at work..."

Informants noted that Rumah Gizi can be effective when held regularly, but attendance was still an issue due to conflicting commitments.

"...Even in Rumah Gizi, there are specific attendees, but some can't come because they have other activities..."

In terms of local policy, informants stressed the importance of reviving nutrition support programs such as Supplemental Feeding, which previously played a vital role in assisting families with stunted children:

"...The nutrition post (Pos Gizi) is no longer active due to funding issues. It used to run for 12 consecutive days. There's still local PMT, but only for pregnant women now—the sessions for toddlers have ended..."

These insights underscore the need for revitalizing and funding community-based nutrition initiatives and ensuring broader parental engagement, particularly among working families, to support sustainable stunting prevention.

DISCUSSION

The study showed that most children had adequate protein intake, with 54.5% in the stunting group and 75.8% in the non-stunting group. However, chi-square analysis indicated no statistically significant association between protein intake and stunting (OR = 2.60; CI95 % = 0.91 to 7.44; p = 0.074). Although protein is essential for linear growth and tissue development (Endrinikapoulos et al., 2023), its adequacy alone may not be sufficient to prevent stunting. Prior studies have highlighted that stunting is multifactorial, affected not only by protein intake but also by energy deficiency, micronutrient deficits, poor sanitation, recurrent infections, and socioeconomic conditions (Rahman and Sari, 2021; Gonzalez and Gracia, 2020). Thus, while protein is critical, broader contextual and nutritional factors must be considered (Raiten and Bremer, 2020).

In this study, 51.5% of children in the stunted group had inadequate fat intake, compared to 30.3% in the non-stunted group. However, this difference was not statistically significant (OR= 2.44; CI95%= 0.89 to 6.70; p= 0.082). Fat plays a vital role in brain development, energy storage, and fat-soluble vitamin absorption (Fadhilah and Hidayat, 2024). Nevertheless, stunting prevention requires sufficient total energy intake from all macronutrients. Studies by Yuwanti et al. (2021) and Sunaryo and Taufik (2019) emphasize that inadequate fat alone is not a primary determinant of stunting, which is often linked to overall diet quality, infections, and environmental conditions. Therefore, fat intake should be addressed as part of a comprehensive dietary and environmental intervention strategy (Nugroho and Lestari, 2023).

Carbohydrate intake was significantly associated with stunting (p=0.015), with 66.7% of children in the stunted group having insufficient carbohydrate intake. Children with inadequate carbohydrate intake were 3.5 times more likely to experience stunting (OR: 3.50; 95% CI: 1.27 to 9.64). Carbohydrates are the main source of energy, essential for tissue formation and metabolic activities. Deficiencies may force the body to use protein for energy, impairing growth (Muthia and Yantri, 2019). Inadequate energy intake, especially during the first 1,000 days of life, is a known predictor of stunting (Beal et al., 2018; Marlina et al., 2022). Findings from the IFLS study support that energy and carbohydrate insufficiency are major contributors to stunting (Mulyaningsih et al., 2021). Complex carbohydrates from whole grains and tubers may support better growth outcomes (Muthia and Yantri, 2019).

Qualitative findings revealed that several factors hinder children's macronutrient intake, including loss of appetite during illness, a preference for snacks over main meals, food texture aversions, and excessive sweet snack consumption. Five of eight informants reported decreased appetite in children during illness, which limited their intake of nutritious food. This aligns with Sari and Handayani (2022), who emphasized the need for health workers to guide parents in providing digestible and energy-dense meals during illness.

Two informants highlighted children's tendency to reject meals after consuming sugary snacks. This behavior may reduce the intake of protein, fat, and fiber. Yuliana and Putri (2023) similarly found that sugary snacks suppress appetite and disrupt main mealtime consumption. Practical strategies include adjusting snack timing, offering healthier alternatives (e.g., fruits, plain yogurt), and involving children in food preparation (Scottish Government, 2024).

Children also showed strong food texture preferences, often favoring crunchy foods over soft ones. In such cases, parents should adjust food textures and presentation to encourage eating (Nicklous and Tournier, 2015). Lastly, several children preferred snacks over balanced meals, which can hinder the intake of essential nutrients. Putri and Hamid (2023) found that such preferences often reduce protein and fiber intake. Nutrition education programs must help parents creatively incorporate nutritious ingredients into child-friendly meals (Njike et al., 2016).

Interviews revealed that mothers often face challenges in feeding routines and lack sufficient knowledge of balanced nutrition. Although many mothers attempted to provide varied foods, particularly protein sources like eggs, main meals were frequently replaced by snacks. Parents noted that children refused meals after eating cakes in the morning. Arini et al. (2023) also observed that sweet snacks often displace more

nutritious foods. Some mothers rarely served fruits and vegetables due to financial limitations or prioritizing protein-based foods, leading to micronutrient deficiencies (Putri et al., 2023). Despite some improvement in protein intake, imbalances in fat, carbohydrate, and micronutrient consumption remain. These findings underscore the need for comprehensive nutrition education focused on balanced diets for young children.

Interview data suggested two key recommendations: improving food variety and delivery for children, and enhancing parental education using simple and repeatable methods. Informants emphasized that diverse food options with appealing presentation help maintain children's interest in eating (Gelman et al., 2023). For parents, educational tools should be practical and easy to understand, such as videos or home visits, to improve long-term behavior change (Varela et al., 2023). Behavioral change interventions should go beyond awareness by incorporating contextual and hands-on strategies. Practical training for mothers on varied food preparation, supported by educational media and consistent follow-up, can improve dietary patterns and help overcome nutritional barriers.

Recommendations also included revitalizing community-based programs such as posyandu and local food supplementation initiatives. Findings indicated that limited participation and operational challenges reduce the effectiveness of these programs. PMT based on local food sources has proven beneficial in reducing stunting risk and increasing food independence (Dewi and Prasetyo, 2024). However, limited human resources and training, low community engagement, and inflexible schedules remain barriers (Yuliantini et al., 2022). Effective strategies include adjusting integrated health post schedules for working mothers, providing continuous training for health volunteers, and strengthening partnerships with the private sectors. Community involvement is also vital to ensure sustainability (Rahmawati and Purnamasari, 2023).

This mixed-methods study explored the relationship between macronutrient intake and the incidence of stunting in children aged 1–2 years within the working area of Dadok Tunggul Hitam Public Health Center in Padang. Quantitative analysis revealed that stunted and non-stunted children shared similar demographic characteristics, including sex, birth weight, and maternal education. However, most stunted children had inadequate energy intake, and fewer of them lived in households with income above the regional minimum wage. In terms of macronutrient intake, insufficient carbohydrate intake was significantly associated with stunting (OR: 3.50; 95% CI: 1.27 to 9.64; $p = 0.015$), while no significant associations were observed for protein or fat intake.

The qualitative findings identified two major themes: barriers to adequate macronutrient intake and recommendations for nutritional intervention at the household level. Barriers from the child's perspective included appetite loss during illness, rejection of main meals after consuming sugary snacks, dislike of soft-textured foods, and preference for snacks over nutrient-rich meals. From the mother's perspective, challenges included limited knowledge about balanced macronutrient intake and difficulties in regulating feeding routines. Additionally, the documentation of child growth and nutrition education at community health posts was found to be suboptimal, with limited educational resources and poor follow-up mechanisms. Overall, the findings underscore the need for integrated and contextual nutrition interventions that target both caregivers and children. Strategies should emphasize improving carbohy-

drate quality and quantity, enhancing maternal nutrition literacy, and strengthening community-based health programs to effectively address stunting in early childhood.

This study has several limitations that should be considered when interpreting the findings. First, macronutrient intake data were collected using a single 24-hour dietary recall, which depends heavily on the caregiver's memory and honesty. This method is subject to recall bias and may not accurately reflect the child's habitual dietary intake. Second, the sample size of the case group was relatively small (n= 33), which, although consistent with a 1:1 case-control design, limits the generalizability and statistical power of the results. Third, the study applied the Indonesian Recommended Dietary Allowance (RDA) for children aged 1–3 years without adjusting for sex-specific nutritional needs, even though energy and nutrient requirements vary between boys and girls. Fourth, as a cross-sectional study, it was not possible to determine causal relationships between nutrient intake and stunting. Fifth, several potential confounding variables—such as maternal education, income, age, employment status, and family size—were not analyzed in depth about stunting outcomes. Sixth, contextual factors such as cultural feeding practices, family dynamics, and parental decision-making were not fully captured in the quantitative component, although qualitative data partially addressed these aspects. Finally, the study's limited time frame restricted the ability to conduct longitudinal observations or track changes in nutritional status over time.

AUTHOR CONTRIBUTION

All author was responsible for the conceptualization and design of the study, data collection, statistical analysis, and interpretation of both quantitative and qualitative findings. The author approved the final version of the manuscript and agrees to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

ACKNOWLEDGMENT

The author would like to thank the supervisor and the examining lecturer for their guidance and direction during this research. Gratitude was also conveyed to the Dadok Tunggul Hitam Health Center and all respondents who had assisted in data collection. The support from family and colleagues was very meaningful in the completion of this article.

FUNDING AND SPONSORSHIP

This study is self-funded.

CONFLICT OF INTEREST

There was no conflict of interest in this study.

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