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Multivariable Logistic Regression of Modifiable Stunting Risk Factors in Kubu Raya

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ABSTRACT

Introduction: Stunting in toddlers remains a public health challenge in Indonesia, especially in areas with high prevalence such as Kubu Raya District, which reaches 25.4%. Although multiple risk factors for stunting have been identified in the broader literature, evidence from district-level settings in West Kalimantan remains limited, and the relative contribution of modifiable determinants within this specific context has not been systematically examined. This study aims to analyze the determinants of stunting in children aged 24–59 months in Kubu Raya District, West Kalimantan.

Methods: A cross-sectional study was conducted on 435 children aged 24–59 months selected through multistage random sampling. Data were collected using a structured questionnaire and anthropometric measurements. The variables studied included the age of introduction of complementary foods (MP-ASI), exclusive breastfeeding, maternal health education (KIE), gestational age, low birth weight (LBW), and birth spacing. Nutritional status was determined based on height-for-age (HAZ) using the 2006 WHO standards. Data analysis used chi-square tests and multiple logistic regression.

Results: The prevalence of stunting reached 40.7% (177 out of 435 infants). In the bivariate analysis, all variables showed a significant association with stunting: inappropriate age for introducing complementary foods (OR=6.527; 95% CI: 2.177-19.567; p=0.000), not receiving exclusive breastfeeding (OR=2.372; 95% CI: 1.827–3.080; p=0.000), lack of exposure to health education (OR=1.285; 95% CI: 1.026–1.610; p=0.032), high-risk pregnancy (OR=1.478; 95% CI: 1.184–1.845; p=0.001), low birth weight (OR=1.483; 95% CI: 1.101–1.997; p=0.024), and risky birth spacing (OR=1.280; 95% CI: 1.022–1.602; p=0.033). Multivariable logistic regression retained absence of exclusive breastfeeding as the sole independent predictor of stunting (AOR = 3.289; 95% CI: 2.096–5.164; p < 0.000; reference: exclusively breastfed).

Conclusion: Exclusive breastfeeding is the primary determinant of stunting prevention after controlling for other risk factors. Stunting prevention programs should prioritize increasing exclusive breastfeeding coverage through comprehensive education, sustained lactation support, and policies that promote optimal breastfeeding practices. Integration of nutritional interventions within the 1000 Days of Life framework is necessary to achieve national stunting reduction targets.

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INTRODUCTION

The toddler years are a critical period, also known as the golden period, which only occurs once in a lifetime and will never be repeated. During this period, the growth and development of the brain, physical development, cognitive development, and personality develop at an extremely rapid pace (1). Therefore, the toddler stage is crucial in determining the quality of a human being. The rapid growth and development during the toddler stage are greatly influenced by adequate nutrition in toddlers, which can lead to various issues, one of which is stunting (2). Driven by prolonged malnutrition and harmful environmental factors, stunting is a lasting developmental setback occurring within the vital 1,000-day period from gestation to age two, a timeframe where nutritional deficiencies lead to permanent damage to a child's physical height and brain maturation (3). Children with stunting are characterized by their height not being appropriate for their age (1-5 years). This condition can significantly undermine a child's developmental trajectory, hindering both their physical coordination and cognitive maturation (4).

Stunting has become a complex and multidimensional global problem, requiring a comprehensive approach to its treatment. Although WHO figures show that world stunting rates decreased from 32.4% in 2000 to 22.3% in 2020, the global burden remains heavy with 149.2 million children under five still affected (5). Over half of the world's stunting instances are concentrated within South and Southeast Asia, a region where Indonesia stands out as a primary contributor to this significant public health challenge (6). A longitudinal study by De Sanctis (2021) showed that stunting in children is closely associated with long-term cognitive deficits, with IQ scores 5-11 points lower than those of non-stunted children (7). Research conducted by Kustanto (2021) established that early childhood stunting is linked to diminished educational outcomes, lower earning potential, and a higher susceptibility to chronic health conditions later in life (8).

Beyond simply reflecting a child's failure to reach their height potential, stunting acts as a vital warning sign for various medical complications, including a heightened vulnerability to long-term illnesses in adulthood (9). Simply put, stunting is short stature, but short stature does not necessarily mean stunting; stunting is only apparent after a child reaches the age of 2 years (10). The developmental gap between stunted children and their healthy counterparts ensures that the effects of the condition ripple outward, ultimately undermining a nation's broader economic growth and social progress (11). The ASEAN Snapshot Report 2022 shows that Cambodia, the Philippines, Vietnam, and Myanmar have seen a decrease in stunting prevalence, while Malaysia, Thailand, and Indonesia have experienced an increase in stunting prevalence (12). However, the latest data indicates a more positive trend for Indonesia. Data from the 2022 Indonesia Nutrition Status Survey (SSGI) reveals a notable decline in the nation's stunting rates, which fell to 21.6% from the previous year's figure of 24.4% (13). Despite ongoing efforts, Indonesia has yet to meet the state mandated goal of lowering stunting frequency to 14% by the year 2024 (14). Data from World Health Organization in 2024 indicate that Indonesia still ranks among the five countries with the highest stunting prevalence globally, with around 4.5 million children under five affected (15). Regional disparities are also significant, with provinces in Eastern Indonesia such as East Nusa Tenggara, Papua, and Central Sulawesi showing high stunting prevalence rates ranging from 25-35% (16).

In 2020, data from the World Health Organization (WHO) reported 150.8 million cases of stunting, or 22.2%(17). Indonesia is one of five countries designated by the WHO as having the highest prevalence of stunting, at 36.4%(18). According to the results of the 2022 Indonesia Nutrition Status Survey (SSGI), the stunting rate in Indonesia was 21.6%, meaning Indonesia accounts for approximately 4.7% of all stunting cases worldwide(19). The 2023 Indonesia Health Survey found that infants most commonly experience stunting in the 2-3 age group. The prevalence of stunting among infants in West Kalimantan is 17.3%, higher than the national average. In Pontianak City itself, it ranks 13th out of 14 districts/cities with a prevalence of 16.7%, while in Kubu Raya District, it reaches 25.4%(20). This indicates that the stunting rate in Kubu Raya District is still far from the WHO target of below 20%(21).

Previous studies have identified various modifiable risk factors for stunting. A journal by Wicaksono et al. (2021) identified that recurrent infections, particularly diarrhea and acute respiratory infections, contribute significantly to stunting through chronic inflammation and malabsorption of nutrients (22). Findings by Izdhihar et al. (2023) in Indonesia indicate that suboptimal breastfeeding and complementary feeding practices are primary contributors to stunting, with infants lacking exclusive breastfeeding facing a 2.1-fold higher risk of the condition(23). A meta-analysis conducted by Putri et al. (2021) established that infants born with low birth weight are 1.8 times

more likely to experience stunting, emphasizing the critical need for nutritional support and healthcare during pregnancy (24).

Stunted children face a substantially higher likelihood of developing chronic, non-communicable diseases such as hypertension, diabetes, obesity, and various forms of cancer as they reach adulthood. UNICEF reports that malnutrition accounts for nearly 50% of deaths among children under five, as it weakens their immune systems, heightens susceptibility to disease, and slows recovery (25). However, many parents still view stunting as normal and believe that their children can still grow because they are still toddlers. The first 24 months of a child's life constitute a critical period in which physical growth and cognitive development are essential for shaping long-term potential.

The causes of stunting are complex and interrelated, categorized by UNICEF into a three-tier hierarchy: immediate factors such as diet and health, intermediate influences including household food security and caregiving practices, and fundamental societal determinants like economic conditions and political environments (3). According to pathway analysis by Stewart et al. (2019), stunting results from the combined influence of multiple factors, including maternal education, household economic status, access to sanitation facilities, and dietary practices working in concert (26). Arsyi (2021) reported that in Indonesia, a combination of maternal characteristics, infant specific factors, and environmental conditions, such as water quality and sanitation, explains 68% of the variation in stunting rates (27).

From an epidemiological perspective, health crises arise when the equilibrium between the host, the agent, and their surroundings is disrupted, meaning stunting stems from host malnutrition influenced by internal variables like caregiving habits, breastfeeding, dietary intake, vaccination history, and genetics (28). Meanwhile, external factors include family socioeconomic conditions, maternal education levels, parental employment status, and the quality of sanitation and drinking water. Kubu Raya District in West Kalimantan is an area of interest for research due to its unique demographic and geographic characteristics. As a district with a stunting prevalence of 25.4%, Kubu Raya shows a rate that is still high compared to the national target. This condition is thought to be related to specific local factors, including community consumption patterns that still rely on single carbohydrates, limited access to animal protein, and suboptimal complementary feeding practices (29). Preliminary research in West Kalimantan by Fadilah et al. (2022) indicates that birth spacing, maternal age, and maternal health education (KIE) are significant predictors of stunting. While multivariate analyses of stunting determinants are well-established in the literature, district-level evidence from Kubu Raya remains limited, warranting contextually grounded investigation to inform local policy and program prioritization (30).

Although various studies have been conducted to identify risk factors for stunting, there is still a knowledge gap that needs to be addressed. First, most previous studies have used univariate or bivariate approaches that are unable to capture the complexity of interactions between risk factors. Second, research in specific regions such as Kubu Raya District is still limited, even though local characteristics greatly determine the effectiveness of intervention programs. Third, no comprehensive study has analyzed modifiable risk factors such as the age of introducing complementary foods, maternal knowledge, education, and communication (KIE), exclusive breastfeeding practices, gestational age, low birth weight (LBW), and birth spacing within an integrated predictive model. To address these research gaps, this study utilizes multivariate analysis to pinpoint independent stunting risk factors in Kubu Raya District while adjusting for potential confounders, ultimately aiming to provide a solid evidence base for localized intervention strategies that align with national 2024 reduction goals.

METHOD

Research Type

This research employed an observational analytic design with a cross-sectional approach to examine the association between risk factors and growth retardation among children aged 24–59 months. The cross-sectional method was selected because it enables simultaneous assessment of both exposure and outcome variables within the same timeframe, making it suitable for identifying the prevalence of growth retardation and its related determinants.

Population and Sample/Informants

This research focuses on the demographic of children between two and five years old who are currently living within the Kubu Raya District of West Kalimantan. This age range was selected based on the consideration that

stunting can be accurately detected and reflects the cumulative impact of various factors since conception. The sample size was set at 435 children based on a proportion estimation formula with a 95% confidence level and a 5% margin of error, considering the local stunting prevalence of 25.4% and a 10% non-response rate. Multistage random sampling proceeded through three stages: sub-district selection, followed by village selection within sub-districts, and systematic selection of eligible children from posyandu registers. Where multiple eligible children resided within the same household, one child was randomly selected to prevent within-household clustering.

Research Location

The research location was Kubu Raya District, West Kalimantan Province, selected due to its high stunting prevalence (25.4%) and diverse geographical and demographic characteristics. The district encompasses a range of areas from urban to rural with heterogeneous socioeconomic levels, enabling researchers to obtain a representative picture of the factors influencing stunting across various environmental settings.

Instrumentation or Tools

The research instruments consisted of a validated structured questionnaire to collect data on sociodemographic characteristics, pregnancy and childbirth history, breastfeeding and complementary feeding practices, and exposure to nutrition education. Anthropometric equipment included a digital scale with a precision of 0.1 kg and a portable stadiometer with a precision of 0.1 cm, calibrated daily before measurements. The nutritional status of toddlers is determined using the height-for-age index (HAZ) with the 2006 WHO growth standards, where toddlers are categorized as stunted if their HAZ z-score is < -2 SD.

Data Collection Procedures

Data collection was conducted over three months by trained enumerators. Coordination with the District Health Office, Community Health Centers, and Posyandu cadres facilitated respondent access. Eligible respondents were identified per inclusion and exclusion criteria, followed by structured interviews with mothers or primary caregivers and duplicate anthropometric measurements; the mean of two measurements was recorded to minimize technical error. A key limitation is reliance on maternal recall for infant feeding practices in children aged 24–59 months. Nondifferential misclassification from extended recall would bias associations toward the null, potentially underestimating true effect sizes. Differential misclassification, whereby mothers of stunted children recalled feeding practices differently, cannot be excluded and may distort associations in unpredictable directions. No triangulation with health records was employed, and this should be considered when interpreting reported effect sizes.

Data Analysis

Statistical processing was carried out through three specific stages using the SPSS version 26.0 software package. The first stage of the study utilized univariate analysis to summarize participant demographics and illustrate the overall distribution of the variables being researched. In the second stage, a bivariate analysis was performed using chi-square tests to examine the links between independent and dependent variables, with the magnitude of these associations expressed through odds ratios and 95% confidence intervals. The final phase consisted of a multidimensional analysis through multiple logistic regression employing the backward elimination technique to pinpoint factors that are independently linked to growth retardation, while controlling for other confounding variables.

Prior to analysis, all variables were dichotomized based on established thresholds. Complementary feeding timing was classified as inappropriate if initiated before or after 6 months of age, and appropriate if initiated at exactly 6 months. Exclusive breastfeeding was defined as breast milk only for the first 6 months, with any supplementation coded as non-exclusive. Maternal gestational age was classified as at-risk if aged <20 or >35 years at delivery. Low birth weight was defined as birth weight <2,500 grams. Birth spacing was classified as at-risk if <24 or >60 months between consecutive births. KIE exposure was dichotomized as never versus ever exposed to any nutrition-related education program. Stunting was defined as height-for-age z-score below −2 SD (WHO Child Growth Standards), coded 1 = stunted and 0 = not stunted.

Ethical Approval

The research received formal ethical clearance from the Health Research Ethics Committee within the Faculty of Health Sciences and Psychology at Universitas Muhammadiyah Pontianak, documented under protocol number 010/KEPK-FIKES/UMPONTIANAK/2023. The study adhered strictly to the ethical principles of respect, beneficence, non-maleficence, and justice. Participants were thoroughly informed about the research objectives, procedures, and potential risks, including their right to withdraw at any time, and written consent was obtained from guardians, with complete anonymity of data maintained.

RESULTS

Data gathered from the participant interviews provided a comprehensive profile of the maternal demographics represented in this research.

Table 1. Respondent Characteristics

No	Variable	Frequency	%
1	Gender		
	Male	230	52,9
	Female	205	47,1
2	Mother's Education		
	Never attended school	14	3,2
	Did not complete elementary school	37	8,5
	Completed elementary school	107	24,6
	Completed junior high school	91	20,9
	Completed senior high school	137	31,5
	Completed Diploma (D1/D2/D3)	17	3,9
	Completed bachlor's degree	32	7,4
3	Father's Occupation		
	Not working	5	1,1
	Civil servant/military/police/state-owned enterprise/regional-owned enterprise	14	3,2
	Private employee	196	45,1
	Entrepreneur	118	27,1
	Farmer/farm laborer/plantation worker	53	12,2
	Laborer/driver/housekeeper	49	11,3
4	Mother's age		
	<25 years old	84	19,3
	25 – 35 years old	229	52,6
	36 – 45 years old	109	25,1
	>45 years old	13	3,0
5	Father's Age		
	<25 years old	31	7,1
	25 – 35 years old	209	48,0
	36 – 45 years old	159	36,6
	>45 years old	36	8,3

Source: Primary Data

According to the data in Table 1, the study participants exhibit a varied distribution across several categories. Of the 435 toddlers who were the subjects of the study, the majority were male (230 children or 52.9%) compared to

female (205 children or 47.1%). Looking at the mothers' educational levels, the majority of mothers had completed upper secondary education (high school/madrasah aliyah) with 137 mothers (31.5%), followed by mothers who had completed primary school/madrasah ibtidaiyah with 107 mothers (24.6%), and those who had completed lower secondary school/madrasah tsanawiyah with 91 mothers (20.9%). Meanwhile, mothers with higher education (diploma and bachelor's degree) accounted for only 11.3% (49 individuals), and 11.7% of mothers (51 individuals) had not completed or never attended school up to the elementary school level.

The characteristics of fathers' occupations are dominated by private sector employees, totaling 196 individuals (45.1%), followed by self-employed individuals, totaling 118 individuals (27.1%). Occupations as farmers/agricultural workers/gardeners and laborers/drivers/domestic helpers each account for 12.2% and 11.3%, respectively. Only a small number of fathers work as civil servants/military/police/state-owned enterprise employees, totaling 14 people (3.2%). The age distribution of mothers shows that the majority are in the productive age group of 25-35 years old, totaling 229 people (52.6%), followed by the 36-45 age group with 109 people (25.1%). There are 84 mothers (19.3%) under the age of 25 and only 13 (3.0%) over the age of 45. A similar pattern is observed in the age distribution of fathers, with the majority in the 25-35 age group (209 individuals or 48.0%) and the 36-45 age group (159 individuals or 36.6%).

Table 2. Univariate Research Results

No	Variable	Frequency	%
1	Age of Complementary Feeding		
	Inappropriate Age of Complementary Feeding (<6 months)	391	89,9
	Appropriate Age of Complementary Feeding (≥6 months)	44	10,1
2	Pregnancy Age		
	At Risk	149	34,3
	Not at Risk	286	65,7
3	Low Birth Weight		
	LBW	38	8,7
	Not LBW	397	91,3
4	Birth Spacing		
	At Risk	180	41,4
	Not at Risk	255	58,6
5	Exclusive breastfeeding		
	Not exclusively breastfed	216	49,7
	Exclusively breastfed	219	50,3
6	Mothers' Knowledge of Communication, Information, and Education		
	Never	156	35,9
	Ever	279	64,1
7	Nutritional Status		
	Stunting	177	40,7
	Not Stunting	258	59,3

Source: Primary Data

Table 2 illustrates the categorical breakdown and frequency of both the explanatory and outcome variables utilized throughout this research. The results show that most infants (391 children or 89.9%) received complementary feeding that was not appropriate for their recommended age, while only 44 children (10.1%) received age-appropriate complementary feeding.

Regarding maternal gestational age, 286 respondents (65.7%) had a non-risk gestational age, while 149 respondents (34.3%) had a risk gestational age. The majority of infants were born with normal birth weight (397 infants or 91.3%), and only 38 infants (8.7%) experienced low birth weight.

Regarding birth spacing, 255 respondents (58.6%) had non-risk birth spacing, while 180 respondents (41.4%) had risk birth spacing. Exclusive breastfeeding showed a nearly balanced distribution, with 219 infants (50.3%) receiving exclusive breastfeeding and 216 infants (49.7%) not receiving exclusive breastfeeding. Regarding exposure to KIE (Communication, Information, and Education), the majority of mothers had been exposed to information about infant nutrition (279 people or 64.1%), while 156 mothers (35.9%) had never been exposed to KIE. The main findings of the study showed a stunting prevalence of 40.7% (177 children) and 59.3% (258 children) with normal nutritional status.

Table 3. Bivariate Research Results

Variable	Categoried				ρ *value*	(95% CI)
	Stunting		Not Stunting			
	F	%	F	%		
Age of Complementary Feeding						
Inappropriate Age of Complementary Feeding	174	44.5	217	55.5	0,000	6,527 (2,177 – 19,567)
Appropriate Age of Complementary Feeding	3	6.8	41	93.2		
Mothers' Knowledge of Communication, Information, and Education						
Never	74	47.4	82	52.6	0,032	1,285 (1,026 – 1,610)
Ever	103	36.9	176	63.1		
Exclusive breastfeeding						
Not exclusively breastfed	124	57.4	92	42.6	0,000	2,372 (1,827 – 3,080)
Exclusively breastfed	53	24.2	166	75.8		
Pregnancy Age						
At Risk	77	51.7	72	48.3	0,001	1,478 (1,184 – 1,845)
Not at Risk	100	35.0	186	65.0		
Low Birth Weight						
LBW	22	57.9	16	42.1	0,024	1,483 (1,101 – 1,997)
Not LBW	155	39.0	242	61.0		
Birth Spacing						
At Risk	84	46.7	96	53.3	0,033	1,280 (1,022 – 1,602)
Not at Risk	93	36.5	162	63.5		

Source: Primary Data

The results of the bivariate analysis indicated that multiple risk factors were statistically associated with the occurrence of stunting within the study population. Inappropriate timing of complementary feeding has a highly significant association with stunting ($p < 0.05$), with an odds ratio of 6.527 (95% CI: 2.177-19.567). This indicates that children introduced to complementary foods at an inappropriate age have a 6.5-fold higher risk of stunting compared to those whose feeding transition follows the recommended schedule. Maternal engagement with nutritional counseling and Information, Education, and Communication (IEC) programs also demonstrated a statistically significant correlation with stunting outcomes (p=0.032). Mothers who had never been exposed to KIE had an odds ratio of 1.285 (95% CI: 1.026–1.610), confirming that insufficient exposure to nutritional information increases the incidence of stunting among infants.

Data revealed a highly significant correlation between exclusive breastfeeding and stunting (p=0.000). Specifically, children who were not exclusively breastfed faced a 2.372 times greater risk of stunting (95% CI: 1.827-3.080) than those who received exclusive breastfeeding for the full duration. Significant correlations were found between high-risk maternal age during pregnancy and stunting (p=0.001), with an odds ratio of 1.478 (95% CI: 1.184–1.845). Furthermore, low birth weight (LBW) was significantly linked to the condition (p=0.024) indicating an odds ratio of 1.483 (95% CI: 1.101–1.997). Similarly, risky birth spacing had a significant association (p=0.033) with children in this category being 1.280 times more likely to experience stunting (95% CI: 1.022–1.602).

Table 4. Multivariate Research Results

No	Variable	β	SE	Wald	Df	Sig	Exp β
1	Exclusive breastfeeding	1,191	,230	26,836	1	,000	3,289
	Constant	-1,488	,343	18,851	1	,000	,226

Source: Primary Data

Following the application of multiple logistic regression using the backward elimination technique, exclusive breastfeeding was the only variable to maintain statistical significance in the concluding model. The analysis indicates that, after adjusting for other factors, children who were not exclusively breastfed faced a 3.289 times higher probability of stunting (AOR = 3.289; 95% Cl:2.096-5.164; Wald = 26.836; Df = 1; p = 0.000).

DISCUSSION

The Relationship Between the Age of Complementary Feeding Introduction and Nutritional Status

The data indicates that children introduced to complementary foods outside of the recommended timeframe were 6.5 times more likely to experience stunting than those whose introduction aligned with established guidelines (OR = 6.527; 95% CI: 2.177–19.567; p < 0.000). These results align with WHO guidelines, which underscore the necessity of initiating complementary feeding at 6 months to ensure healthy developmental outcomes and physical growth (31). Introducing complementary foods too early can disrupt the immature digestive system of infants, while introducing them too late can lead to nutritional deficiencies. This reflects the fact that, beyond the six-month mark, exclusive breastfeeding no longer provides the complete nutritional profile required to satisfy an infant's accelerating developmental demands (32). Similar conclusions were drawn in Indonesia by Puspitorini et al. (2021), where inappropriate timing of complementary feeding was the primary determinant of stunting. Inappropriate timing of complementary feeding can involve early introduction (<6 months), which may cause diarrhea and recurrent infections, or delayed introduction (>6 months), which may lead to growth faltering due to an unmet energy gap (33). The high proportion of inappropriate MP-ASI administration (89.9%) in this study indicates a lack of understanding among mothers about the optimal timing for MP-ASI administration. Previous research has also shown that certain food restrictions among the Dayak Nganju community, especially among women in Central Kalimantan Province, can have an impact on their health (34). This may be due to local cultural factors, family influence, or a lack of accurate information from healthcare providers. Intensive educational interventions on the proper timing and composition of MP-ASI are crucial for stunting prevention (35).

The Relationship between Mothers' Knowledge of Communication, Education, and Information and Nutritional Status

The study found that limited maternal access to Information, Education, and Communication (IEC) services was associated with a 1.3-fold increase in the likelihood of stunting in toddlers compared to those whose mothers received adequate exposure (OR = 1.285; 95% CI: 1.026–1.610; p = 0.032). Research indicates that a lack of maternal engagement with Information, Education, and Communication (IEC) programs correlates with a 1.3-fold increase in the risk of stunting among their children. This finding underscores the importance of nutrition education programs in preventing stunting, aligning with UNICEF's conceptual framework on the indirect causes of stunting (36). Mothers' knowledge of nutrition and good feeding practices are protective factors against stunting. Effective KIE can enhance mothers' understanding of infants' nutritional needs, exclusive breastfeeding practices, and appropriate introduction of complementary foods. Findings from Goudet et al. (2019) suggest that implementing nutritional education

interventions for mothers can lead to a 20% reduction in the prevalence of stunting (37). However, the effectiveness of IEC does not only depend on the frequency of exposure, but also on the quality of the message, the method of delivery, and its suitability to the local cultural context. IEC programs that are developed must take into account mothers' educational levels and use communication media that are easily understood by the local community.

The Relationship Between Exclusive Breastfeeding and Nutritional Status

The findings demonstrate that the absence of exclusive breastfeeding was associated with a 2.4-fold increase in the odds of stunting compared to children who were exclusively breastfed (OR = 2.372; 95% CI: 1.827–3.080; p < 0.000). Statistical modeling indicates that, when adjusting for confounding factors, the risk of stunting was more than threefold higher for infants who did not receive exclusive breastfeeding. These results reinforce the vital importance of exclusive breastfeeding as a primary stunting prevention strategy and align with international scientific consensus. Exclusive breastfeeding provides optimal protection against stunting through several mechanisms: first, breast milk provides a nutritionally optimal profile tailored specifically to support an infant's physiological development throughout the initial six months of life; second, breast milk provides essential antibodies and immunological components that serve to shield infants from various infectious diseases; third, breast milk is easily digestible and has high bioavailability (38). A journal by Sintje et al. (2025) indicates that exclusive breastfeeding practices are associated with a 19% reduction in the risk of stunting (39). The fact that nearly 50% of infants in this study missed exclusive breastfeeding indicates ongoing challenges in implementing exclusive breastfeeding programs. Factors such as insufficient maternal knowledge, inadequate family support, maternal work conditions, and formula milk promotion can hinder the success of exclusive breastfeeding programs (40). Comprehensive interventions involve not only maternal education but also family support and supportive policies such as adequate maternity leave and lactation facilities at the workplace.

The Relationship between Gestational Age and Nutritional Status

The analysis identified that children born to mothers with a high-risk gestational age faced a 1.5-fold increase in the odds of stunting compared to those born at a non-risk gestational age (OR = 1.478; 95% CI: 1.184–1.845; p = 0.001). Maternal age during pregnancy that falls outside the optimal range, specifically those under 20 or over 35 years, is linked to a higher incidence of gestational complications and can negatively impact the nutritional development of the fetus (33). Pregnancy at a young age is often associated with suboptimal maternal nutritional status and incomplete reproductive maturity, while pregnancy at an older age increases the risk of medical complications. Longitudinal studies indicate that the mother’s age at pregnancy influences birth weight and subsequent child growth (41). Mothers who become pregnant at an optimal age (20–35 years) tend to have better nutritional status and health, enabling them to provide optimal nutrition for the fetus (42). Implementing family planning initiatives and preconception counseling is essential to promote healthy timing for pregnancy. Key strategies involve expanding access to reproductive health services, providing education on optimal childbearing age, and enhancing the nutritional health of adolescent girls as a foundational step for future maternal and fetal well-being(43). A life cycle approach to stunting prevention should begin in adolescence to prepare healthy prospective mothers.

The Relationship Between LBW and Nutritional Status

Data indicates that children born with low birth weight (LBW) experience a 1.5-fold increase in the odds of stunting compared to those born within a normal weight range (OR = 1.483; 95% CI: 1.101–1.997; p = 0.024). This finding is consistent with scientific evidence showing that LBW is a strong risk factor for growth faltering in infants and toddlers. LBW can be caused by Intrauterine Growth Restriction (IUGR) or preterm birth, both of which impact long-term growth. LBW infants typically have limited nutrient reserves, an immature immune system, and a high risk of infection (44). Cohort studies show that catch-up growth in LBW infants often fails to reach full genetic potential, thereby increasing the risk of stunting (45). Preventing LBW requires interventions starting from the preconception and pregnancy periods, including improving maternal nutritional status, iron and folic acid supplementation, routine pregnancy monitoring, and managing pregnancy complications (46). Integrated programs between nutrition services, maternal and child health (MCH), and health promotion are key to the success of LBW prevention.

The Relationship between Birth Spacing and Nutritional Status

Toddlers with non-ideal birth spacing (<24 months or >60 months) had 1.3 times higher odds of stunting compared to those with ideal birth spacing (OR = 1.280; 95% CI: 1.022–1.602; p = 0.033). Birth spacing that is too close does not allow enough time for mothers to recover their nutritional status, so that the next pregnancy is at risk of nutritional deficiency (47). Conversely, birth intervals that are too long can result in mothers losing their experience in caring for children. Optimal birth intervals (24–60 months) allow mothers time to recover physiologically and psychologically, prepare family resources, and provide optimal attention to each child (48). Research shows that birth intervals of less than 18 months increase the risk of stunting by up to 40% compared to birth intervals of 24-35 months (49). Effective family planning programs with appropriate contraceptive options are key to regulating optimal birth intervals. Postpartum family planning counseling and integration with nutrition services can help families plan appropriate birth intervals to prevent stunting.

Multivariate Analysis

After adjustment for all other variables, absence of exclusive breastfeeding remained the sole independent predictor significantly associated with stunting (AOR = 3.289; 95% CI: 2.096–5.164; Wald = 26.836; p < 0.001). This indicates that exclusive breastfeeding is the most dominant protective factor against stunting after controlling for other variables. This finding reinforces the evidence that exclusive breastfeeding is the most cost-effective intervention in preventing stunting. Although other factors such as the age of complementary feeding initiation, maternal knowledge, education, and information (KIE), gestational age, low birth weight (LBW), and birth spacing are important, their effects become insignificant when the status of exclusive breastfeeding is accounted for in the model (50).

These results suggest multicollinearity among the measured variables; mothers who practiced exclusive breastfeeding tended to also introduce complementary foods at the recommended age and demonstrated higher nutritional knowledge, indicating that positive feeding behaviors cluster within the same household context (51). Stunting prevention programs should therefore address exclusive breastfeeding as a foundational entry point while simultaneously reinforcing complementary feeding practices and maternal nutrition literacy (52). Several limitations must be acknowledged. The cross-sectional design precludes causal inference, as all associations reflect co-occurrence at a single time point. More critically, core structural determinants, including household socioeconomic status, sanitation access, dietary diversity, and household food security, were not measured, introducing residual confounding that may distort the observed associations. Self-reported feeding data are additionally susceptible to recall bias, which may partly explain the exceptionally high prevalence of inappropriate complementary feeding timing (89.9%). Future longitudinal research incorporating these structural variables is needed to more fully elucidate stunting pathways in this setting. Despite these limitations, findings carry actionable policy relevance. Programs should prioritize breastfeeding coverage through integrated prenatal and postnatal education, lactation support, and workplace policies conducive to breastfeeding (53). Achieving sustained stunting reductions will further require multi-sectoral coordination to address the structural determinants, food insecurity and inadequate sanitation, that this study was unable to capture (54).

CONCLUSION

Evidence from this study verifies that exclusive breastfeeding serves as the primary protective factor against stunting (AOR = 3.289) within the Kubu Raya District, even after adjusting for multiple confounding variables. While bivariate analysis identified significant correlations with modifiable determinants, including the timing of complementary food introduction, access to health education, gestational age, low birth weight, and birth spacing, exclusive breastfeeding persists as the most economically viable and impactful intervention for stunting prevention. Stunting programs in endemic areas should prioritize strategies to increase exclusive breastfeeding coverage through a comprehensive approach that includes prenatal-postnatal education, sustained lactation support, workplace policies conducive to breastfeeding, and regulations on formula milk marketing. Integrating exclusive breastfeeding interventions with other optimal nutrition practices within the framework of the 1,000 Days of Life will yield maximum synergistic effects toward achieving the national target of reducing stunting to 14% by 2024.

AUTHOR CONTRIBUTION STATEMENT

Linda Suwarni contributed as the principal investigator responsible for conceptualizing the research, developing the methodology, supervising data collection, analyzing and interpreting the results, and writing and revising the manuscript. Selviana played a role in the research design, field coordination, data collection and validation, statistical analysis, and contributed to the writing and review of the manuscript. Both authors have read, approved, and are responsible for the entire content of the published manuscript, and ensure the accuracy and integrity of every aspect of the reported research.

CONFLICT OF INTEREST

The authors hereby declare that there are no financial or personal conflicts of interest that could influence the objectivity and neutrality of this research. The authors have no financial, commercial, or personal relationships with individuals, organizations, or entities that could unduly influence the results of this research. This research was conducted independently without pressure or influence from external parties that could compromise scientific integrity. This statement is made to maintain the credibility and transparency of the research and to ensure that the findings and conclusions are purely based on objective analysis of the collected data.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors used AI-assisted technology in the form of Grammarly to help improve grammar, spelling, and sentence structure in English in the abstract and keywords, as well as DeepL to ensure the accuracy of the translation of several technical terms from Indonesian to English. The use of AI is limited to technical aspects of writing and does not involve the data analysis process, interpretation of results, development of arguments, or drawing of research conclusions. All concepts, ideas, methodologies, and research findings are the result of the authors' pure intellectual work. The authors remain fully responsible for the accuracy, validity, and originality of all scientific content presented in this manuscript.

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