



Exclusive Breastfeeding, Gestational Age, and Maternal Nutrition Associated with Infant Weight for Age Status: A Cross-Sectional Study

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Abstract

Weight-for-age is a key indicator of early growth, and infants whose weight falls below the red line (bawah garis merah, BGM) of the Indonesian growth chart (KMS) need prompt follow-up. This study examined the associations of exclusive breastfeeding, gestational age at delivery, and maternal nutritional status during pregnancy with infant BGM status. This study used a quantitative analytic design with a cross-sectional approach. The population comprised infants registered at Biru Public Health Center, Bone Regency, in March–April 2024, and the sample consisted of 35 mother–infant pairs selected by purposive sampling. Data were collected through structured interviews with mothers using a checklist and questionnaire and verified against Maternal and Child Health (KIA) book records; maternal nutritional status was based on self-reported dietary adequacy. Data were analysed univariately and bivariate with Fisher's exact test, and associations were expressed as odds ratios (OR) with 95% confidence intervals (CI). The results of the study show that nine infants (25.7%) were BGM and that BGM status was associated with non-exclusive breastfeeding (OR 24.00; 95% CI 3.25–177.41; $p = 0.001$), preterm birth (OR 87.50; 95% CI 6.88–1,112.37; $p < 0.001$), and inadequate maternal nutrition (OR 19.25; 95% CI 2.88–128.52; $p = 0.001$). The very wide intervals reflect the small sample, and the estimates were not adjusted for confounding. These exploratory findings suggest that preterm and non-exclusively breastfed infants, and mothers with inadequate diets during pregnancy, should be prioritised for growth monitoring and nutrition counselling, and they need confirmation in larger studies using multivariable analysis.

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1. INTRODUCTION

Weight-for-age is one of the most sensitive anthropometric indicators of nutritional status and growth in early life. The first 1000 days, from conception to the second birthday, form a critical window in which nutrition strongly shapes physical growth and organ development, and deficits acquired during this period are difficult to reverse later (Likhar & Patil, 2022). Adequate weight gain in the first months of life therefore reflects the quality of feeding and care that an infant receives. Underweight and failure to thrive, by contrast, are associated with higher risks of infection, developmental delay, and death, especially in low- and middle-income settings (McNelis et al., 2025; Victora et al., 2021).

To protect early growth, the World Health Organization recommends exclusive breastfeeding (EBF), that is, giving the infant only breast milk with no other food or fluid, for the first six months of life (World Health Organization, 2023; Meek & Noble, 2022). Breast milk supplies a balanced, developmentally matched profile of macronutrients and micronutrients together with immunoglobulins, growth factors, and other bioactive components that support growth and protect against gastrointestinal and respiratory infection (Brockway et al., 2024; Hossain & Mihrshahi, 2022). Suboptimal breastfeeding is consistently linked to higher infant morbidity and mortality (Pérez-Escamilla et al., 2023), whereas EBF is associated with better infant nutritional status and a lower risk of stunting in Indonesian settings (Rochmawati & Kusmintarti, 2024; Hadi et al., 2021; Simbolon & Putri, 2024). Despite these benefits, EBF coverage in Indonesia remains below national targets; a national survey reported that only about half of working mothers (51.9%) practised EBF in 2021 (Ipa et al., 2024), leaving many infants exposed to early nutritional risk.

Gestational age at delivery is a second key influence on infant weight. Infants born at term (37–42 weeks) generally achieve more favourable weight trajectories than those born preterm (<37 weeks), who often present with low birth weight and are prone to growth faltering because of organ immaturity, metabolic instability, and feeding difficulty (Jasper et al., 2021). Many preterm infants do not reach the growth velocity expected for their corrected age, and the consequences can persist into childhood (McNelis et al., 2025; Kresnawati et al., 2025).

Maternal nutritional status during pregnancy and lactation is a third pathway. Maternal dietary intake is correlated with both breast-milk composition and subsequent infant growth, while poor maternal diet, low dietary diversity, and inadequate gestational weight gain are recognised contributors to low birth weight (Mexitalia et al., 2022; Jan Mohamed et al., 2022; Kheirouri & Alizadeh, 2021). Maternal nutrition behaviour, in turn, is shaped by food literacy and nutritional self-efficacy, which can be strengthened through targeted education during pregnancy (Fitriani et al., 2026). Micronutrient deficiency adds further risk; suboptimal maternal iron status during pregnancy, for example, is associated with adverse child health outcomes (Quezada-Pinedo et al., 2021). In Indonesia, chronic energy deficiency among pregnant women remains common (Harna et al., 2024), and cultural food taboos that restrict nutrient-dense foods among pregnant and lactating women, as documented in South Sulawesi, may worsen maternal deficiency (Nurbaya & Nurcahyani, 2024). Consistent with these pathways, national survey data identify maternal characteristics and socio-economic factors, including pregnancy complications, as significant determinants of low birth weight in Indonesia (Yuniar et al., 2022).

Local surveillance data make these issues pressing in Bone Regency. Among all public health centers in the district, Biru Public Health Center recorded the highest proportion of infants below the red line (BGM) during January–July 2024. Health-center records show that about one in five registered infants was BGM in each recent year: 61 of 302 infants in 2021, 67 of 318 in 2022, 71 of 327 in 2023, and 20 of 104 during January–

April 2024. This persistently high burden of low weight-for-age warrants a focused study of its associated factors in the local population.

Most Indonesian studies of these factors have used stunting (length-for-age) or birth weight as the outcome and have usually examined exclusive breastfeeding, gestational age, or maternal nutrition separately (Hadi et al., 2021; Simbolon & Putri, 2024; Yuniar et al., 2022). Much less is known about BGM status, the weight-for-age screening indicator that midwives and posyandu cadres use in routine growth monitoring to decide on referral and supplementary feeding. Evidence from rural South Sulawesi is particularly limited, although pregnant women in this province face the national burden of chronic energy deficiency (Harna et al., 2024) together with documented local food taboos that restrict nutrient-dense foods during pregnancy and lactation (Nurbaya & Nurcahyani, 2024). This study addresses that gap by examining feeding, obstetric, and maternal-nutrition factors against the routine BGM indicator in a health center with a persistently high BGM burden, so that the findings can guide which mothers and infants Puskesmas staff should prioritise. The study aimed to examine the associations of exclusive breastfeeding, gestational age at delivery, and maternal nutritional status during pregnancy with BGM weight-for-age status among infants at Biru Public Health Center, Bone Regency, in 2024.

2. METHODS

This analytic cross-sectional study was conducted at Biru Public Health Center, Bone Regency, South Sulawesi Province, Indonesia; data were collected from March to April 2024. The study is reported in accordance with the STROBE guideline for cross-sectional studies. The study population comprised infants registered at Biru Public Health Center during March–April 2024. The sample size was initially derived with the Slovin formula at a 10% margin of error, which gave 35 mother–infant pairs. Because this formula estimates a descriptive proportion and is not a power-based calculation for association testing, the study is presented as an exploratory analysis of the eligible mother–infant pairs available during the study period, and the precision of each estimate is reported with 95% confidence intervals (CI). Participants were recruited by purposive sampling using three inclusion criteria: (1) the infant was registered at Biru Public Health Center; (2) the infant was domiciled in Bone Regency; and (3) the infant had complete weight-monitoring records in the Maternal and Child Health (KIA) book. Infants with incomplete records were excluded.

Data were drawn from primary and secondary sources. Primary data were collected through structured interviews with mothers using a checklist and questionnaire, and the answers were checked against the KIA book. Exclusive breastfeeding was defined, following WHO (World Health Organization, 2023), as feeding the infant only breast milk, with no other food or fluid apart from medicines, vitamins, or oral rehydration solution, from birth to six months of age; infants who had received any other food or fluid before six months were classified as non-exclusively breastfed. Gestational age at delivery was taken from the maternal report, verified against the delivery record in the KIA book, and classified as preterm (<37 completed weeks) or term (37–42 weeks). Maternal nutritional status during pregnancy was assessed with questionnaire items on whether the mother had met her dietary needs during pregnancy and was classified as adequate or inadequate. This variable therefore reflects self-reported dietary adequacy, not an anthropometric measure such as mid-upper arm circumference (MUAC) or chronic energy deficiency (CED) status, which were not part of the study dataset.

Infant weight status was taken from the weight-monitoring records in the KIA book and classified on the KMS growth chart (Kartu Menuju Sehat) as normal (on or above the red line) or BGM (below the red line). The KMS is based on the WHO Child Growth

Standards, and its red line corresponds to a weight-for-age z-score (WAZ) of -3 SD (World Health Organization & UNICEF, 2019; Wulandari & Arum, 2022). BGM therefore identifies severely low weight-for-age and is not equivalent to underweight as defined by WHO (WAZ < -2 SD) (Ministry of Health of the Republic of Indonesia, 2020; World Health Organization & UNICEF, 2019). Because individual z-scores were not calculated, infants with a WAZ between -3 and -2 SD were classified as normal in this study. Infant age at weighing, sex, and birth weight were not included in the analysis.

Data were edited, coded, tabulated, and cleaned before analysis in IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armonk, NY, USA). Univariate analysis described the frequency distribution of each variable. For bivariate analysis, a 2×2 contingency table was constructed for each independent variable against BGM status. Because every table contained at least one cell with an expected frequency below five, the two-sided Fisher's exact test was used instead of the Pearson Chi-square test, with significance set at $p < 0.05$. The strength of each association was expressed as an odds ratio (OR) with a 95% CI (Woolf method); prevalence ratios (PR) with 95% CIs were also calculated because the outcome was not rare. Multivariable logistic regression was not performed because the nine BGM cases were too few to fit a stable model with three predictors according to current sample-size guidance for logistic regression (Riley et al., 2020).

Ethical principles were applied throughout the study, which was conducted in accordance with the principles of the Declaration of Helsinki. Research permits were obtained from the Bone Regency Health Office and Biru Public Health Center, and the study was conducted following ethical approval from the Health Research Ethics Committee of Politeknik TEDC Bandung (ethical approval No. 015PKE-080124, issued in 2024). We obtained written informed consent from all mothers before data collection. Respondent confidentiality was preserved by using coded identifiers instead of personal names, and the data were used only for research purposes.

3. RESULTS AND DISCUSSION

Table 1. Frequency distribution of variables at Biru Public Health Center (n = 35).

Variable	Frequency (f)	Percentage (%)
Weight-for-age status (KMS)		
Normal (on or above the red line)	26	74.3
BGM (below the red line)	9	25.7
Exclusive breastfeeding		
Yes	27	77.1
No	8	22.9
Gestational age		
Preterm (<37 weeks)	8	22.9
Term (37–42 weeks)	27	77.1
Maternal nutritional status (self-reported)		
Adequate	24	68.6
Inadequate	11	31.4
Total	35	100.0

Note: BGM = *bawah garis merah* (below the red line of the KMS growth chart, corresponding to weight-for-age below -3 SD); maternal nutritional status was self-reported.

Of the 35 infants, 26 (74.3%) had normal weight-for-age and 9 (25.7%) were BGM. Most infants had been exclusively breastfed (77.1%) and born at term (77.1%), and most mothers reported adequate nutrition during pregnancy (68.6%) (Table 1).

Table 2. Association between exclusive breastfeeding and BGM status (n = 35).

Exclusive breastfeeding	BGM	Normal	Total	OR (95% CI)	p-value*
	n (%)	n (%)	n		
Yes	3 (33.3)	24 (92.3)	27	24.00	0.001
No	6 (66.7)	2 (7.7)	8	(3.25–	
Total	9 (100.0)	26 (100.0)	35	177.41)	

Note: OR = odds ratio for non-exclusive vs. exclusive breastfeeding (reference); CI = confidence interval (Woolf method); *two-sided Fisher's exact test.

BGM status was associated with exclusive breastfeeding (Fisher's exact p = 0.001). Six of the eight non-exclusively breastfed infants (75.0%) were BGM, compared with 3 of 27 exclusively breastfed infants (11.1%) (OR 24.00; 95% CI 3.25–177.41; PR 6.75; 95% CI 2.16–21.09) (Table 2).

Table 3. Association between gestational age and BGM status (n = 35).

Gestational age	BGM	Normal	Total	OR (95% CI)	p-value*
	n (%)	n (%)	n		
Term (37–42 weeks)	2 (22.2)	25 (96.2)	27	87.50	<0.001
Preterm (<37 weeks)	7 (77.8)	1 (3.8)	8	(6.88–	
Total	9 (100.0)	26 (100.0)	35	1,112.37)	

Note: OR = odds ratio for preterm vs. term birth (reference); CI = confidence interval (Woolf method); *two-sided Fisher's exact test.

Gestational age showed the strongest association with BGM status (Fisher's exact p < 0.001). Seven of the eight preterm infants (87.5%) were BGM, compared with 2 of 27 term infants (7.4%) (OR 87.50; 95% CI 6.88–1,112.37; PR 11.81; 95% CI 3.03–45.98) (Table 3).

Table 4. Association between maternal nutritional status and BGM status (n = 35).

Maternal nutritional status	BGM	Normal	Total	OR (95% CI)	p-value*
	n (%)	n (%)	n		
Adequate	2 (22.2)	22 (84.6)	24	19.25	0.001
Inadequate	7 (77.8)	4 (15.4)	11	(2.88–	
Total	9 (100.0)	26 (100.0)	35	128.52)	

Note: OR = odds ratio for inadequate vs. adequate maternal nutrition (reference); CI = confidence interval (Woolf method); *two-sided Fisher's exact test.

Maternal nutritional status was also associated with BGM status (Fisher's exact p = 0.001). Seven of the 11 infants whose mothers reported inadequate nutrition (63.6%) were BGM, compared with 2 of 24 infants whose mothers reported adequate nutrition (8.3%) (OR 19.25; 95% CI 2.88–128.52; PR 7.64; 95% CI 1.88–30.97) (Table 4). For all three factors the confidence intervals were very wide, so the size of each association is estimated imprecisely.

DISCUSSION

In this exploratory study, about one in four infants attending Biru Public Health Center was below the red line, and BGM status was associated with non-exclusive breastfeeding, preterm birth, and self-reported inadequate maternal nutrition. The

direction of these associations agrees with earlier Indonesian studies. A cross-sectional study at Penerokan Public Health Center reported a relationship between exclusive breastfeeding and appropriate infant weight gain (Hariyanti, 2026), and studies in Bogor and eastern Indonesia, together with a national meta-analysis and a literature review, linked exclusive breastfeeding with better nutritional status and a lower risk of stunting (Rochmawati & Kusmintarti, 2024; Hadi et al., 2021; Simbolon & Putri, 2024; Erwani et al., 2023). Two mechanisms may explain the association with breastfeeding. Breast milk provides nutrients and bioactive components, including growth factors and human milk oligosaccharides, that are related to infant growth and to a gut microbiome associated with better feeding tolerance (Brockway et al., 2024; Ford et al., 2019). Breast milk also protects against infection: infants who are not exclusively breastfed have more diarrhoeal and respiratory illness and a markedly higher risk of infection-related death (Hossain & Mahrshahi, 2022; Meek & Noble, 2022; Pérez-Escamilla et al., 2023), and repeated illness slows weight gain. Reverse causation is also possible in a cross-sectional design, because mothers of infants who gain weight slowly may introduce formula or other foods early when they perceive their milk to be insufficient.

The large odds ratio for preterm birth is consistent with evidence that preterm birth is a major cause of low birth weight and later growth impairment (Jasper et al., 2021). Preterm infants have limited energy and fat reserves and immature digestive and metabolic function, and many do not reach the growth velocity expected for their corrected age (McNelis et al., 2025); in resource-limited settings, poor growth can persist during follow-up (Kresnawati et al., 2025). Part of this association may also reflect how weight is plotted: a preterm infant plotted on the KMS by chronological rather than corrected age appears lighter for age, so some preterm infants classified as BGM may be growing appropriately for their corrected age. Birth weight was not analysed, and it may lie on the pathway between preterm birth and later BGM status or confound the other associations.

Infants of mothers who reported inadequate nutrition during pregnancy were also more often BGM. This agrees with evidence that maternal dietary intake is correlated with breast-milk composition and infant growth, and that poor maternal diet, low dietary diversity, and chronic energy deficiency are associated with low birth weight (Mexitalia et al., 2022; Jan Mohamed et al., 2022; Kheirouri & Alizadeh, 2021; Harna et al., 2024). Maternal undernutrition may limit fetal growth, and poor maternal iron status has been linked to adverse child health outcomes (Quezada-Pinedo et al., 2021). In South Sulawesi, food taboos that restrict several nutrient-dense foods during pregnancy and lactation have been documented among indigenous communities (Nurbaya & Nurcahyani, 2024). Such taboos may partly explain why some mothers in this area reported not meeting their dietary needs, although the present study did not measure them. Because the nutrition variable was self-reported, it is subjective and open to recall and social desirability bias, and it should not be read as equivalent to anthropometric nutritional status.

Within these limits, the findings point to practical steps for the health center. Midwives could ask about food taboos at the first antenatal visit and discuss them in antenatal classes (*kelas ibu hamil*) with husbands, mothers-in-law, and community leaders present, so that culturally acceptable alternatives to restricted foods are agreed within the family. Pregnant women with a MUAC below 23.5 cm or other signs of chronic energy deficiency could be enrolled in supplementary feeding with monthly follow-up. Breastfeeding counselling could continue at postnatal and *posyandu* visits, with early contact when a mother starts formula or other foods before six months. Preterm infants could be flagged at birth for more frequent weighing, with weight interpreted by corrected age and referral when growth falters (Fitriani et al., 2026; Erwani et al., 2023).

This study has several limitations. The sample was small and purposively selected from one health center, there were only nine BGM cases, and the sample size was not based on a power calculation, so the study may have been too small to detect weaker associations. The estimates are imprecise, as the very wide confidence intervals show, and they cannot be generalised to Bone Regency as a whole. The small number of outcome events did not allow multivariable logistic regression, so all odds ratios are unadjusted. Because maternal nutrition, gestational age, and breastfeeding are interrelated (for example, poor maternal nutrition raises the risk of preterm birth, and preterm infants are less often exclusively breastfed), the three associations are not independent, and the factor contributing most to BGM status could not be identified. Infant age, sex, and birth weight were not included in the analysis and may confound the observed associations. Maternal nutritional status relied on self-report rather than objective measures such as MUAC or CED records, and the KMS red line identifies only severely low weight-for-age ($WAZ < -3$ SD), so some underweight infants may have been classified as normal. Finally, the cross-sectional design does not allow causal or temporal conclusions. Larger studies with power-based sample sizes, WHO z-scores, objective maternal anthropometry, and multivariable or longitudinal analysis are needed to confirm these findings.

4. CONCLUSION

This exploratory study examined whether exclusive breastfeeding, gestational age, and maternal nutritional status during pregnancy were associated with BGM weight-for-age status among infants at Biru Public Health Center. Non-exclusive breastfeeding, preterm birth, and self-reported inadequate maternal nutrition were more common among BGM infants, but these associations are unadjusted, imprecise because of the small single-center sample, and cannot be interpreted as causal.

For practice, the findings support three targeted actions at the health center: community-based nutrition counselling in antenatal classes that addresses local food taboos during pregnancy together with family members and community leaders; routine MUAC screening with supplementary feeding for pregnant women with chronic energy deficiency; and closer growth monitoring, assessed by corrected age, for preterm and non-exclusively breastfed infants. A larger study using WHO weight-for-age z-scores, objective maternal anthropometry, and multivariable analysis is needed to confirm which of these factors contributes most to low weight-for-age in this population.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Sulfianti conceived and designed the study, supervised data collection, and drafted the manuscript. Lina Fitriani contributed to the study design and to the analysis and interpretation of the data. Hasnidar contributed to the development of the research instruments and to data interpretation. Nur Eva Sapartina contributed to data collection, data processing, and preparation of the tables. Rochmawati critically revised the manuscript for important intellectual content. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

During the preparation and revision of this manuscript, the authors used Claude (Anthropic), a generative AI tool, to improve the English language and readability of the text and to cross-check the recalculation of Fisher's exact tests, odds ratios, and confidence intervals from the contingency tables. The study design, data collection, choice of analysis, and interpretation of the findings were carried out by the authors. The authors reviewed and edited all AI-assisted output and take full responsibility for the accuracy, originality, and integrity of the manuscript.

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