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Original Article

Maternal risk of chronic energy deficiency based on mid-upper arm circumference and low birth weight among term singleton births: A retrospective record-based study in Lampung, Indonesia

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Abstract

Background: Low birth weight remains a major neonatal health concern. Mid-upper arm circumference (MUAC) is routinely used in Indonesia to screen pregnant women for risk of chronic energy deficiency (CED), but its association with low birth weight among term births requires careful interpretation.
Objective: To examine the association between maternal risk of CED based on antenatal MUAC and low birth weight among term singleton births at Dr. H. Abdul Moeloek Regional General Hospital, Lampung, Indonesia.
Methods: This retrospective record-based analytic study included 93 term singleton mother-infant pairs selected consecutively from 178 eligible delivery records from January to August 2025. Maternal risk of CED was defined as the most recent documented antenatal MUAC <23.5 cm; MUAC >=23.5 cm was classified as not at risk. Low birth weight was defined as birth weight <2,500 g. Sample adequacy was reassessed using a single-proportion approach with 95% confidence, an expected proportion of 0.50, 7.5% precision, finite-population correction, and 5% allowance for incomplete records, producing a minimum of 92 records. Pearson chi-square and crude odds ratio (OR) with 95% confidence interval (CI) were calculated.
Results: Forty infants (43.0%) had low birth weight, and 20 mothers (21.5%) were at risk of CED. Low birth weight occurred in 18 of 20 mothers at risk of CED (90.0%) and in 22 of 73 mothers not at risk (30.1%). Maternal risk of CED was associated with low birth weight ($p < 0.001$; crude OR = 20.864; 95% CI = 4.455-97.718). The wide CI indicates substantial uncertainty in the magnitude of the estimate.
Conclusion: Maternal risk of CED based on MUAC was associated with low birth weight among term singleton births. The finding supports consistent antenatal MUAC screening, but it should be interpreted as an unadjusted hospital-based association that requires confirmation in larger studies with standardized MUAC timing and multivariable adjustment.

Background

Low birth weight is defined as a birth weight below 2,500 g and may result from fetal growth restriction, prematurity, or both. It is associated with increased neonatal morbidity, mortality, impaired growth, and later health risks. Birth weight should ideally be measured shortly after delivery before clinically meaningful postnatal weight loss occurs (World Health Organization, 2023; UNICEF, 2023).

Indonesia continues to report low birth weight across provinces, although prevalence varies according to data source and completeness of birth-weight recording. Lampung Province also reports persistent low-birth-weight cases across districts and cities (Dinas Kesehatan Provinsi Lampung, 2022; Kementerian Kesehatan Republik Indonesia, 2023). Hospital surveillance remains relevant because referral hospitals often care for mothers with higher obstetric risk than the general population.

Maternal undernutrition can limit energy and nutrient reserves needed for placental function and fetal growth. In Indonesian antenatal services, MUAC <23.5 cm is commonly used as a practical screening threshold for risk of CED. MUAC is inexpensive and feasible, but it is a screening indicator rather than a complete measure of maternal nutritional status. It should therefore be described specifically as risk of CED based on MUAC and interpreted together with other maternal and obstetric factors.

A 2025 systematic review and meta-analysis found that maternal undernutrition during pregnancy was associated with higher odds of low birth weight, although effect estimates varied across studies (Asferie et al., 2025). Indonesian studies have also reported associations between

maternal MUAC, body mass index, or other nutritional indicators and birth weight, but findings differ by design, population, timing of assessment, and control of confounding (Putri & Wahyuni, 2020; Herwati et al., 2021; Listiarini et al., 2022; Riantika et al., 2022; Zulfikar et al., 2023; Sekriptini et al., 2025).

Hospital records at Dr. H. Abdul Moeloek Regional General Hospital showed 179 low-birth-weight infants among 391 recorded births in 2024 and 58 low-birth-weight infants among 178 recorded births from January to August 2025. These hospital figures should not be interpreted as population prevalence, but they indicate a substantial clinical burden in the referral setting. Updated analysis was needed to describe the association between routinely documented antenatal MUAC and birth weight among term singleton births. This study therefore examined the association between maternal risk of CED based on MUAC and low birth weight at the hospital in 2025.

Methods

Study Design

This study used a retrospective record-based analytic design with a cross-sectional analytic framework. Maternal MUAC had been documented during antenatal care before delivery, and birth weight had been documented at delivery. The research team subsequently abstracted both variables from existing records for each mother-infant pair. The manuscript was organized according to the STROBE and RECORD reporting principles for observational studies using routinely collected health data (von Elm et al., 2007; Benchimol et al., 2015).

Setting

The study was conducted at Dr. H. Abdul Moeloek Regional General Hospital, a referral hospital in Lampung Province, Indonesia. Data sources were held in the maternity ward, perinatology ward, medical record unit, and Maternal and Child Health handbook documentation. Delivery records dated January 1-August 31, 2025 were reviewed after ethical approval.

Population and Sampling

The accessible population comprised 178 recorded term singleton deliveries, including 58 infants recorded as low birth weight and 120 infants recorded as having birth weight >=2,500 g. The unit of analysis was the mother-infant pair. Records were screened consecutively against the eligibility criteria, and eligible complete records were included until the required sample was reached. The term accidental sampling was removed because it did not accurately describe the record-selection process.

The original report stated that a Lemeshow formula had been used but did not preserve the assumptions required to reproduce that calculation. To avoid presenting unsupported parameters, sample adequacy was reassessed transparently using the single-proportion formula. A conservative expected proportion of 0.50, 95% confidence level (Z = 1.96), and absolute precision of 0.075 produced an initial sample of 170.74. Applying finite-population correction for N = 178 produced 87.40; adding 5% for incomplete records produced 91.77, rounded to a minimum of 92 records. The final sample of 93 mother-infant pairs exceeded this minimum. Power is not an input parameter in this single-proportion precision-based calculation (Naing et al., 2022).

Eligibility Criteria

Records were eligible when they represented a mother who delivered a live singleton infant at >=37 completed weeks of gestation, included a documented birth weight, and contained an antenatal MUAC value in the Maternal and Child Health handbook, hospital record, or verified digital image of the relevant handbook page. Multiple pregnancies were excluded. Records with missing exposure or outcome data were not included.

Variables and Operational Definitions

The exposure was maternal risk of CED based on MUAC. A documented antenatal MUAC <23.5 cm was classified as at risk of CED, whereas MUAC >=23.5 cm was classified as not at risk. This wording replaced the broader terms poor and good maternal nutritional status because MUAC alone does not represent all dimensions of maternal nutrition. The outcome was low birth weight, defined as birth weight <2,500 g; birth weight >=2,500 g was classified as not low birth weight.

Potential confounders identified a priori were maternal age, education, parity, anemia, hypertension, gestational diabetes, obesity,

dyslipidemia, and other recorded maternal conditions. These variables were summarized descriptively. Complete participant-level coding required for a valid adjusted model and outcome-stratified comparison was not available across all records; consequently, no multivariable estimate was generated, and the reported OR is explicitly described as crude.

Data Sources, Measurement, and Bias Control

MUAC was abstracted from the most recent antenatal record available before delivery. When a physical Maternal and Child Health handbook was unavailable, a digital image was accepted only after verification of the mother's identity, the measurement date, and the recorded value. Birth weight was abstracted from the perinatology record and represented the infant's weight measured immediately after birth using the hospital baby scale. Data were entered into a structured extraction form, and selected records were independently rechecked to reduce transcription errors.

Gestational age at the MUAC measurement was not consistently documented in a form that permitted standardization or adjustment. MUAC timing could therefore vary between mothers, creating potential exposure misclassification. Restricting the analysis to term singleton births reduced heterogeneity due to prematurity and multiple pregnancy but did not eliminate confounding or measurement bias.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics. Frequencies and percentages described maternal characteristics, risk of CED, and birth-weight status. Pearson chi-square tested the association between risk of CED and low birth weight because all expected cell counts exceeded 5. Fisher's exact test was also examined as a sensitivity analysis and produced the same inference ($p < 0.001$). The crude OR and 95% CI were calculated from the 2 x 2 table. Statistical significance was set at $p < 0.05$, and values below 0.001 were reported as $p < 0.001$. No adjusted model was fitted because complete individual-level confounder data were unavailable.

Ethical Considerations

The study was approved by the Ethics Committee of RSUD Dr. H. Abdul Moeloek (No. 641/KEPK-RSUDAM/XI/2025). Mothers received information about the study, confidentiality, voluntary participation, and withdrawal rights, and written informed consent was obtained when handbook verification required participant contact. Extracted data were coded and used only for research purposes.

Results

A total of 93 eligible mother–infant pairs were included in the final analysis. The results are presented in two sections. First, the maternal characteristics, recorded maternal conditions, risk of chronic energy deficiency based on mid-upper arm circumference, and infant birth-weight status are described. Second, the crude association between maternal risk of chronic energy deficiency and low birth weight among term singleton births is presented (See Table 1).

Table 1. Overall characteristics of the 93 mother-infant pairs

Variable	Category	n	%
Maternal age	<20 years	5	5.4
	20-35 years	48	51.6
	>35 years	40	43.0
Education	Elementary education	9	9.7
	Secondary education	30	32.3
	Higher education	45	48.4
	Postgraduate education	9	9.7
Parity	Primigravida	19	20.4
	Multigravida	74	79.6
Recorded maternal condition*	Anemia	18	19.4
	Gestational diabetes	4	4.3
	Obesity	2	2.2
	Hypertension	10	10.8
	Dyslipidemia	1	1.1

Risk of CED based on MUAC	At risk (<23.5 cm)	20	21.5
	Not at risk (>=23.5 cm)	73	78.5
Birth-weight status	Low birth weight (<2,500 g)	40	43.0
	Not low birth weight (>=2,500 g)	53	57.0

Most mothers were aged 20-35 years (51.6%), had higher education (48.4%), and were multigravida (79.6%). Anemia (19.4%) and hypertension (10.8%) were the most frequently recorded maternal conditions. Twenty mothers (21.5%) were classified as at risk of CED based on MUAC, and 40 infants (43.0%) had low birth weight.

Table 2. Crude association between maternal risk of CED and low birth weight

Risk of CED based on MUAC	LBW n	%	Not LBW n	%	Total n	%	p-value	Crude OR (95% CI)
At risk (<23.5 cm)	18	90.0	2	10.0	20	100.0	<0.001	20.864
Not at risk (>=23.5 cm)	22	30.1	51	69.9	73	100.0		(4.455-
Total	40	43.0	53	57.0	93	100.0		97.718)

Low birth weight occurred in 18 of 20 mothers at risk of CED (90.0%) compared with 22 of 73 mothers not at risk (30.1%). The association was statistically significant (Pearson chi-square = 22.952, df = 1, $p < 0.001$). Mothers at risk of CED had higher crude odds of delivering a low-birth-weight infant (OR = 20.864; 95% CI = 4.455-97.718). The confidence interval was wide, reflecting limited precision and the small number of mothers at risk of CED who delivered an infant without low birth weight.

Discussion

This retrospective record-based study identified an association between maternal risk of CED based on MUAC and low birth weight among term singleton births. Low birth weight was considerably more frequent among mothers with MUAC <23.5 cm than among mothers with MUAC >=23.5 cm. The result is an unadjusted hospital-based association and does not establish causality.

The finding is biologically plausible because inadequate maternal energy and nutrient reserves may impair placental function and restrict fetal growth. Restricting the sample to term births reduces the contribution of prematurity to low birth weight, making impaired fetal growth a more plausible explanation. However, fetal growth restriction was not directly diagnosed, and maternal MUAC alone cannot identify the specific nutritional or placental pathway involved.

The direction of the association is consistent with the 2025 meta-analysis by Asferie et al., which reported higher adjusted odds of low birth weight among undernourished pregnant women. Indonesian studies using MUAC, body mass index, and other maternal nutrition indicators have also generally reported an association with birth weight (Putri & Wahyuni, 2020; Herwati et al., 2021; Riantika et al., 2022; Zulfikar et al., 2023; Sekriptini et al., 2025). Variation between studies may reflect differences in nutritional indicators, gestational timing, referral patterns, eligibility criteria, and confounder adjustment.

MUAC should not be interpreted as a complete measure of maternal nutritional status. It is a practical screening measure for risk of CED. Its value in routine antenatal care lies in identifying women who may require a more comprehensive nutrition assessment. The current study therefore supports consistent documentation and follow-up of MUAC rather than assuming that MUAC alone explains the infant's birth weight.

The crude OR was large, but the 95% CI ranged from 4.455 to 97.718. This wide interval indicates that the strength of the association is estimated imprecisely. Only two mothers in the at-risk MUAC group delivered infants without low birth weight, so a small change in cell counts could substantially alter the OR. The result should therefore be communicated as evidence of a strong direction of association, not as a precise estimate that mothers are exactly 20.864 times more likely to have a low-birth-weight infant.

Confounding remains the principal limitation. Maternal age, education, parity, anemia, hypertension, gestational diabetes, obesity, and other obstetric factors may be related to both

maternal nutrition and fetal growth. Complete individual-level coding was not available to construct a valid stratified table or multivariable logistic regression. The analysis therefore cannot determine whether the observed association is independent of these factors. The high proportion of mothers aged >35 years and the presence of anemia and hypertension further support cautious interpretation.

Additional limitations include consecutive selection of complete records, possible selection bias, variation in gestational age at MUAC measurement, and potential documentation error in routinely collected records. The hospital is a referral center, so the 43.0% low-birth-weight proportion in the sample should not be generalized to Lampung Province. The study also excluded preterm and multiple births, limiting applicability to term singleton births. Future research should use standardized first- or second-trimester MUAC measurement, preserve individual-level confounder data, compare characteristics by birth-weight group, and use prespecified multivariable modeling in a larger sample.

The practical implication should remain proportionate to the measured exposure. Antenatal services should record MUAC consistently and use MUAC <23.5 cm as a signal for further nutritional assessment and closer observation of fetal growth according to existing clinical protocols. This study did not directly test supplementation, hemoglobin monitoring, or referral interventions; therefore, it cannot determine their effectiveness.

Conclusion and Recommendation

Maternal risk of chronic energy deficiency based on antenatal MUAC <23.5 cm was associated with low birth weight among term singleton births at Dr. H. Abdul Moeloek Regional General Hospital. The crude association was large but imprecise and may be affected by unmeasured or unadjusted confounding. Consistent MUAC screening and documentation are supported as risk-identification practices. Confirmation requires larger studies with standardized MUAC timing, outcome-stratified participant characteristics, and multivariable analysis.

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Declaration of conflict of interest
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Declaration on the Use of AI
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Data Availability Statement
Data sharing is not applicable to this article.

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