



Determinants of Chronic Energy Deficiency Among Pregnant Women in Keruak East Lombok: A Case-Control Study

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ABSTRACT

Chronic Energy Deficiency (CED) among pregnant women remains an important public health problem because it is associated with adverse maternal and neonatal outcomes, including anemia, low birth weight, and pregnancy complications. Keruak Primary Health Center reported one of the highest CED rates in East Lombok, with a prevalence of 13.67% in 2024. This study aimed to identify factors associated with CED among pregnant women in the working area of Keruak Primary Health Center, East Lombok. This quantitative analytical study used an unmatched case-control design based on secondary data from maternal health records from January to December 2024. The study population consisted of 1,117 pregnant women, and the sample included 338 respondents, comprising 169 pregnant women with CED and 169 pregnant women without CED selected using a 1:1 case-control ratio. Data were analyzed using chi-square tests and multivariate logistic regression. Bivariate analysis showed significant associations between CED and maternal education, parity, body mass index (BMI), frequency of antenatal care (ANC) visits, hemoglobin level, and iron tablet consumption. BMI in this study referred to the BMI recorded during pregnancy in the maternal health records. In the final multivariate model, BMI showed the strongest association with CED (OR=23.209; 95% CI: 8.463–63.651), followed by parity (OR=2.754; 95% CI: 1.554–4.880), hemoglobin level (OR=2.527; 95% CI: 1.385–4.612), and ANC attendance (OR=1.925; 95% CI: 1.027–3.609). These findings indicate that maternal nutritional status, parity, ANC utilization, and anemia are important factors associated with CED among pregnant women. Strengthening nutritional screening, preconception care, ANC follow-up, hemoglobin monitoring, iron-folic acid supplementation counseling, and targeted nutritional support may help improve early identification and management of pregnant women at risk of CED.

Keywords: Chronic Energy Deficiency, Pregnant Women, Body Mass Index, Antenatal Care, Anemia, Maternal Nutrition.

ABSTRAK

Kurang Energi Kronis (KEK) pada ibu hamil masih menjadi masalah kesehatan masyarakat yang penting karena berhubungan dengan luaran buruk pada ibu dan bayi, termasuk anemia, berat badan lahir rendah, dan komplikasi kehamilan. Puskesmas Keruak melaporkan prevalensi KEK sebesar 13,67% pada tahun 2024, sehingga diperlukan analisis terhadap faktor-faktor yang berhubungan dengan KEK di wilayah tersebut. Penelitian ini bertujuan untuk menganalisis faktor-faktor yang berhubungan dengan KEK pada ibu hamil di wilayah kerja Puskesmas Keruak, Lombok Timur. Penelitian ini merupakan penelitian analitik kuantitatif dengan desain kasus-kontrol berdasarkan data sekunder dari rekam medis ibu pada periode Januari hingga Desember 2024. Populasi penelitian terdiri dari 1.117 ibu hamil, dengan sampel sebanyak 338 responden yang terdiri dari 169 ibu hamil dengan KEK dan 169 ibu hamil tanpa KEK yang dipilih menggunakan rasio kasus-kontrol 1:1. IMT dalam penelitian ini merujuk pada IMT yang tercatat selama kehamilan dalam rekam medis ibu. Data dianalisis menggunakan uji chi-square dan regresi logistik multivariat. Hasil analisis bivariat menunjukkan adanya hubungan yang signifikan antara KEK dengan tingkat pendidikan ibu ($p=0,031$), paritas ($p=0,000$), IMT yang tercatat selama kehamilan ($p=0,000$), frekuensi kunjungan antenatal care (ANC) ($p=0,036$), kadar hemoglobin ($p=0,000$), dan konsumsi tablet zat besi ($p=0,030$). Pada model akhir analisis multivariat, IMT yang tercatat selama kehamilan menunjukkan hubungan paling kuat dengan KEK (adjusted OR=23,209; 95% CI: 8,463–63,651), diikuti oleh pendidikan ibu (adjusted OR=2,754; 95% CI: 1,554–4,880), kadar hemoglobin (adjusted OR=2,527; 95% CI: 1,385–4,612), dan kunjungan ANC (adjusted OR=1,925; 95% CI: 1,027–3,609). Temuan ini menunjukkan bahwa status gizi ibu, latar belakang pendidikan, pemanfaatan layanan ANC, dan status anemia merupakan faktor penting yang berhubungan dengan KEK pada ibu hamil. Penguatan skrining gizi sejak dini, edukasi kesehatan ibu, tindak lanjut kunjungan ANC, pemantauan kadar hemoglobin, konseling kepatuhan konsumsi tablet zat besi, serta dukungan gizi yang tepat sasaran dapat mendukung identifikasi dan penatalaksanaan dini ibu hamil yang berisiko mengalami KEK.

Kata Kunci: Kurang Energi Kronis, Ibu Hamil, Indeks Massa Tubuh, Antenatal Care, Anemia, Gizi Ibu.

INTRODUCTION

Malnutrition continues to devastate the health of adolescent girls and women globally. It is estimated that over one billion adolescent girls and women worldwide are affected by at least one form of malnutrition, and two out of every three are deficient in vital vitamins and minerals (United Nations Children's Fund (UNICEF), 2024). Chronic Energy Deficiency (CED) refers to a prolonged state of inadequate energy consumption, which can be detected using indicators such as mid-upper arm circumference (MUAC) falling below the established threshold (Aswar & Istyanto, 2024). CED among pregnant women in developing nations is a serious public health issue, with reported prevalence ranging between 25% and 43.1%. It is associated with poor birth outcomes, including increased risks of low birth weight and neonatal complications (Al Maeka et al., 2025). Prevalence rates of CED among pregnant women differ across regions, with documented rates of 30.6% in West Java, 32% in Banyumas, and 35.2% in rural Indonesia (Harahap, 2025; Wati, 2024).

CED has been shown to increase the likelihood of low birth weight by 3.45 times. Contributing risk factors include advanced maternal age, high parity, and insufficient dietary intake. Beyond its immediate effects on birth outcomes, CED can have lasting consequences, including impaired cognitive development in children (Al Maeka et al., 2025). According to WHO data, 73.2% of maternal deaths are linked to CED, and women affected by this condition face a 20-fold higher risk of mortality compared to women with a normal arm circumference (Raehan et al., 2025). Addressing CED remains a challenge in developing countries like Indonesia, which has incorporated it as a national target within the 2015–2030 Sustainable Development Goals (SDGs), with a target of reducing CED prevalence among pregnant women to 5% (Siregar et al., 2022).

The study highlights that maternal undernutrition in low- and middle-income countries is influenced by multiple interrelated factors, including inadequate dietary intake, illness, low body mass index, short maternal stature, suboptimal gestational weight gain, anaemia, and micronutrient deficiencies. Low BMI among women is commonly associated with insufficient food intake and disease. At the same time, short stature reflects long-term and intergenerational undernutrition caused by poor nutrition and environmental conditions during early life and adolescence. The article also emphasizes that poor diet quality, limited intake of animal-source foods, iron deficiency, vitamin and mineral deficiencies, and infections contribute to anaemia and poor maternal nutritional status. In addition, socioeconomic inequalities, poverty, low maternal and paternal education, household wealth differences, early marriage, gender-related food distribution inequalities, and limited access to health and nutrition services are important underlying determinants. Overall, maternal undernutrition is not caused by a single factor but results from a combination of biological, dietary, socioeconomic, and environmental conditions that affect women before and during pregnancy (Victora et al., 2021).

The study conducted in rural kebeles of Dera District, North West Ethiopia, found that several socioeconomic, dietary, environmental, and household factors influenced Chronic Energy Deficiency (CED) among women of reproductive age. The main determinants identified were large family size, low educational status, inadequate meal frequency, absence of home gardening, and lack of latrine facilities. Women from larger families were more likely to experience CED because household food resources may be shared among more members, and women may have a greater workload. Low education was also associated with CED because women with limited education may have lower nutritional knowledge and reduced access to health information. Inadequate meal frequency directly contributed to insufficient energy intake, while the absence of home gardens limited access to diverse and nutritious foods. In addition, the lack of latrine facilities increased the risk of infection, which can worsen nutritional status and contribute to chronic undernutrition (Wubie et al., 2020).

CED among pregnant women in Indonesia remains a significant public health challenge, exacerbated by socioeconomic disparities and limited access to nutritious food. Despite government interventions like supplementary feeding programs and iron-folic acid supplementation, its prevalence is still high, with regional variations. This situation necessitates a multifaceted approach to address the nutritional needs of pregnant women effectively. CED affects approximately 14% of pregnant women in Indonesia, with prevalence rates varying from

11,3% to 57,6% across different regions. Key determinants of CED include maternal age, education level, and area of residence, with lower educational attainment and rural living conditions correlating with higher CED rates. Limited access to nutritious food and healthcare services further exacerbates the issue, particularly in underserved regions (Tarina & Mutahar, 2023). Low energy and protein intake are significant contributors to CED. Studies indicate that inadequate dietary intake correlates with higher CED prevalence, with protein intake being particularly critical (Wati et al, 2024). Younger maternal age (<20 years) and higher parity are associated with increased CED risk. For instance, women with one child have a higher likelihood of CED. Low educational attainment and poor nutritional knowledge significantly correlate with CED, emphasizing the need for educational interventions (Tejayanti, 2020). Regular ANC visits are crucial for monitoring maternal health. Studies show that low ANC frequency is linked to higher CED rates (Irma et al, 2025). Pregnant women with low BMI and CED are at increased risk of complications such as anemia, stunted fetal growth, and low birth weight (LBW) babies. A BMI below 18.5 kg/m² is a critical marker for CED, indicating insufficient nutritional intake and energy reserves (Mu'minah et al, 2025).

The 2023 Indonesian Health Survey reported a national CED prevalence of 16.9% among pregnant women. Data from the West Nusa Tenggara Provincial Health Office showed that 31,830 pregnant women were at risk of or experienced complications in 2023, equivalent to 147% of the projected figure. The two most common obstetric complications were CED (14,209 cases) and anemia (12,833 cases). In East Lombok, approximately 25,648 pregnant women were recorded in 2023, of whom 8,727 experienced obstetric complications, a 170% increase, including 3,465 cases of CED (Dinas Kesehatan Provinsi NTB, 2023; Kementerian Kesehatan Republik Indonesia, 2023).

Based on the 2024 PWS KIA data, the Keruak Community Health Center served 1,117 pregnant women from January to December, of whom 169 (13.67%) had CED (Puskesmas Keruak, 2024). In 2023, the same health center had recorded 182 CED cases out of 1,154 pregnant women, representing the highest CED rate among all 35 community health centers in East Lombok (Dinas Kesehatan Kabupaten Lombok Timur, 2023). At the regional level, West Nusa Tenggara (NTB), particularly East Lombok Regency, continues to face substantial nutritional challenges. Several reports indicate that maternal nutritional problems, including CED, are still prevalent in this area, with 12.9% experiencing this condition. Factors such as poverty, early marriage, cultural dietary practices, and limited access to quality antenatal care services may contribute to the persistence of this issue. In East Lombok, a significant relationship exists between maternal CED and the degree of stunting in children, highlighting the intergenerational impact of maternal nutrition. Keruak Subdistrict, as one of the areas in East Lombok, presents unique socio-demographic and health service characteristics that may influence the nutritional status of pregnant women (Ariendha et al., 2024; Selamet, Megatsari, & Hair, 2024).

Previous studies have identified various determinants of CED among pregnant women, including maternal age, parity, educational level, household income, dietary intake, and access to health services. However, findings across different settings have been inconsistent, and there is limited evidence focusing specifically on rural and socio-culturally distinct areas such as Keruak. Moreover, most existing studies have been conducted at national or provincial levels, which may not adequately capture locally specific factors influencing maternal nutritional status. Although previous studies have reported several factors associated with CED among pregnant women, including maternal age, parity, education, dietary intake, household income, BMI, anemia, and access to antenatal care, the evidence remains inconsistent across different geographic and sociocultural settings. Many existing studies have been conducted at national or provincial levels, which may not sufficiently explain local patterns of maternal undernutrition in rural areas. Keruak has specific contextual characteristics, including persistent maternal nutrition problems, rural living conditions, possible socioeconomic constraints, cultural dietary practices, and variations in ANC utilization, which may be associated with the majority of pregnant women with CED (88.4%) the occurrence of CED among pregnant women. Therefore, local evidence is needed to identify factors associated with CED in this specific setting and to support the development of more targeted maternal nutrition interventions. Therefore, this study aims to analyze the determinants of Chronic Energy Deficiency among pregnant women in Keruak, East

Lombok. Understanding these determinants is essential for developing targeted and context-specific interventions to improve maternal nutrition and ultimately reduce adverse pregnancy outcomes in the region.

RESEARCH METHODS

This quantitative analytical study used an unmatched case-control design to identify factors associated with Chronic Energy Deficiency (CED) among pregnant women in the working area of Keruak Primary Health Center from January to December 2024. The source population consisted of all 1,117 pregnant women registered during the study period. The case group included all eligible pregnant women diagnosed with CED, defined as mid-upper arm circumference (MUAC) <23.5 cm. In contrast, the control group consisted of pregnant women without CED, defined as MUAC ≥23.5 cm, who were registered in the same health center and during the same period. A total of 338 respondents were included, comprising 169 cases and 169 controls selected using a 1:1 case-control ratio. No individual matching was performed between cases and controls; therefore, potential confounding variables were considered during the analysis using bivariate analysis and multivariate logistic regression. The sample size was determined based on the total number of eligible CED cases available during the study period, and an equal number of controls was selected to maintain the 1:1 ratio. The inclusion criteria for the case group were pregnant women diagnosed with CED, having complete maternal health records, and residing in the Keruak Primary Health Center working area. The inclusion criteria for the control group were pregnant women without CED, having complete maternal health records, and residing in the same working area. Pregnant women with incomplete maternal health records were excluded, and complete-case analysis was applied without data imputation. Variables analyzed included maternal age, maternal education, occupation, parity, BMI, ANC attendance, hemoglobin level, iron tablet consumption, husband's education, and husband's occupation. Maternal age and socioeconomic-related variables, including maternal occupation, husband's education, and husband's occupation, were considered as potential confounders. Direct household income was not available in the maternal health records; therefore, socioeconomic status was assessed using available proxy variables. BMI refers to the BMI recorded during pregnancy in the maternal health records. BMI was categorized as underweight (<18.5 kg/m²), normal (≥18.5 kg/m²), overweight 25.0–29.0 kg/m²), and obese (>30.0 kg/m²) (Fatiah et al., 2023; Kementerian Kesehatan Republik Indonesia, 2025). Variables that were statistically significant in the bivariate analysis and variables considered theoretically relevant, including maternal age and socioeconomic-related variables, were considered in the multivariate logistic regression model to control for potential confounding. Ethical clearance was obtained from the Health Research Ethics Committee of Poltekkes Kemenkes Mataram with approval number DP.04.03/F.XLVIII.14/134/2025. All data were treated confidentially, personal identifiers were not disclosed, and the information was used solely for research purposes.

RESULTS

Table 1. Frequency distribution of respondents' characteristics with and without chronic energy deficiency.

Characteristics	Frequency of Pregnant Women			
	With CED		Without CED	
	f	%	f	%
Maternal Age				
High-risk age (<20 years and >35 years)	51	15.1%	43	12.7%
Reproductive age (20–35 years)	118	34.9%	126	37.3%
Maternal Education				
No formal education–Elementary school	27	8.0%	47	13.9%
Junior–Senior high school	124	36.7%	106	31.4%
Higher education	18	5.3%	16	4.7%
Maternal Occupation				
Employed	12	3.6%	19	5.6%

Characteristics	Frequency of Pregnant Women			
	With CED		Without CED	
	f	%	f	%
Unemployed	157	46.4%	150	44.4%
Parity				
Primigravida	91	26.9%	32	9.5%
Multigravida	77	22.8%	128	37.9%
Grand multipara	1	0.3%	9	2.7%
Body Mass Index (BMI)				
Underweight (<18.5 kg/m ²)	74	21.6%	4	1.2%
Normal (≥18.5 kg/m ²)	96	28.4%	103	30.5%
Overweight (25.0-29.0 kg/m ²)	0	0.0%	44	13.0%
Obese (>30.0 kg/m ²)	0	0.0%	18	5.3%
Frequency of ANC Visits				
<6 visits	63	18.6%	45	13.3%
≥6 visits	106	31.4%	124	36.7%
Hemoglobin Level				
Anemia <11 g/dL	83	24.6%	40	11.8%
Normal ≥11 g/dl	86	25.4%	129	38.2%
Number of Children				
<5	169	50%	169	50%
≥5	0	0	0	0
Iron Tablet Consumption				
<90 tablets	23	6.8%	11	3.3%
≥90 tablets	146	43.2%	158	46.7%
Husband's Education				
No formal education–Elementary school	47	13.9%	60	17.8%
Junior–Senior high school	105	31.1%	93	27.5%
Higher education	17	5.0%	16	4.7%
Husband's Occupation				
Farmer/Laborer	123	36.4%	125	37.0%
Employee/Self-employed	46	13.3%	44	13.6%

Table 1 shows the characteristics of 338 pregnant women included in this study, consisting of 169 women with Chronic Energy Deficiency (CED) and 169 women without CED. Most respondents in both groups were aged 20–35 years, with 118 women (34.9%) in the CED group and 126 women (37.3%) in the non-CED group. Most mothers had junior to senior high school education, especially in the CED group (36.7%). Most respondents were unemployed, accounting for 46.4% in the CED group and 44.4% in the non-CED group.

Based on parity, primigravida mothers were more common in the CED group (26.9%), while multigravida mothers were more common in the non-CED group (37.9%). Most respondents had a normal BMI, although underweight BMI was more frequently found among women with CED. The majority of respondents had attended ANC visits ≥6 times, especially in the non-CED group (36.7%).

Anemia (Hb <11 g/dL) was more common among pregnant women with CED (24.6%), while normal hemoglobin levels were more common in the non-CED group (38.2%). All respondents had fewer than five children. Most women in both groups consumed ≥90 iron tablets during pregnancy. Regarding husbands' characteristics, most had junior to senior high school education and worked as farmers or laborers.

Table 2. Factors associated with chronic energy deficiency among pregnant women in the working area of keruak primary health center.

Variables	Frequency of Pregnant Women				Total N=338	p-value
	With CED		Without CED			
	n	%	n	%		
Maternal Age						
High-risk age (<20 years and >35 years)	51	15.1%	43	12.7%	100%	0.331
Reproductive age (20–35 years)	118	34.9%	126	37.3%		
Maternal Education						
No formal education–Elementary school	27	8.0%	47	13.9%		100% 0.031
Junior–Senior high school	124	36.7%	106	31.4%		
Higher education	18	5.3%	16	4.7%		
Maternal Occupation						
Employed	12	3.6%	19	5.6%	100%	0.187
Unemployed	157	46.4%	150	44.4%		
Parity						
Primigravida	91	26.9%	32	9.5%		100% 0.000
Multigravida	77	22.8%	128	37.9%		
Grandmultipara	1	0.3%	9	2.7%		
Body Mass Index (BMI)						
Underweight (<18.5 kg/m ²)	74	21.6%	4	1.2%		100% 0.000
Normal (≥18.5 kg/m ²)	96	28.4%	103	30.5%		
Overweight (25.0-29.0 kg/m ²)	0	0.0%	44	13.0%		
Obese (>30.0 kg/m ²)	0	0.0%	17	5.3%		
Frequency of ANC Visits						
<6 visits	63	18.6%	45	13.3%	100%	0.036
≥6 visits	106	31.4%	124	36.7%		
Hemoglobin Level						
Anemia <11 g/dL	83	24.6%	40	11.8%	100%	0.000
Normal ≥11 g/dl	86	25.4%	129	38.2%		
Number of Children						
<5	169	50%	169	50%	100%	-
≥5	0	0	0	0		
Iron Tablet Consumption						
<90 tablets	23	6.8%	11	3.3%	100%	0.030
≥90 tablets	146	43.2%	158	46.7%		
Husband's Education						
No formal education–Elementary school	47	13.9%	60	17.8%		100% 0.311
Junior–Senior high school	105	31.1%	93	27.5%		
Higher education	17	5.0%	16	4.7%		
Husband's Occupation						
Farmer/Laborer	123	36.4%	125	37.0%	100%	0.806
Employee/Self-employed	46	13.3%	44	13.6%		

Based on Table 2, the chi-square test showed that several factors were significantly associated with the occurrence of Chronic Energy Deficiency (CED) among pregnant women ($p < 0.05$). These factors included maternal education ($p = 0.031$), parity ($p = 0.000$), body mass index (BMI) ($p = 0.000$), frequency of antenatal care (ANC) visits ($p = 0.036$), hemoglobin level ($p = 0.000$), and iron tablet consumption ($p = 0.030$). In contrast, no significant association was found between CED and maternal age ($p = 0.331$), maternal occupation ($p = 0.187$), husband's education ($p = 0.311$), or husband's occupation ($p = 0.806$). The variable number of children could

not be analyzed further because all respondents had fewer than five children, resulting in a constant value across the study population.

Table 3. Multivariate analysis of factors associated with chronic energy deficiency among pregnant women in the working area of Keruak Primary Health Center.

Variables	B	p-value	OR	95% C.I. for EXP(B)	
				Lower	Upper
Step 1					
Maternal education	-.212	0.428	0.809	0.478	1.367
Number of Children	.992	0.001	2.698	1.503	4.844
BMI	3.141	0.000	23.128	8.427	63.479
Frequency of ANC Visits	.664	0.075	1.938	0.935	4.016
Hemoglobin Level	.902	0.003	2.465	1.346	4.514
Iron Tablet Consumptions	-.011	0.985	0.989	0.334	2.929
Constant	-9.998	0.000	0.000		
Step 2					
Maternal education	-.212	0.428	0.809	0.478	1.367
Number of Children	.992	0.001	2.695	1.514	4.797
BMI	3.141	0.000	23.123	8.427	63.446
Frequency of ANC Visits	.658	0.041	1.931	1.027	3.629
Hemoglobin Level	.902	0.003	2.465	1.347	4.511
Constant	-10.011	0.000	0.000		
Step 3					
Maternal education	1.013	0.001	2.754	1.554	4.880
BMI	3.145	0.000	23.209	8.463	63.651
Frequency of ANC Visits	.655	0.041	1.925	1.027	3.609
Hemoglobin Level	.927	0.003	2.527	1.385	4.612
Constant	-10.493	0.000	0.000		

Table 3 presents the results of the multivariate logistic regression analysis of factors associated with Chronic Energy Deficiency (CED) among pregnant women in the working area of Keruak Primary Health Center. The final model (Step 3) showed that maternal education, body mass index (BMI), frequency of antenatal care (ANC) visits, and hemoglobin level were significantly associated with the occurrence of CED.

Among these variables, BMI was identified as the strongest predictor of CED (OR=23.209; p=0.000). Pregnant women with abnormal BMI were approximately 23 times more likely to experience CED compared to those with normal BMI. Maternal education was also significantly associated with CED (OR=2.754; p=0.001), indicating that mothers with lower educational levels had a higher risk of developing CED. In addition, pregnant women with inadequate ANC visits were nearly two times more likely to experience CED (OR=1.925; p=0.041). Hemoglobin level was another important factor, with anemic mothers having a 2.5 times greater risk of CED compared to mothers with normal hemoglobin levels (OR=2.527; p=0.003). The findings suggest that nutritional status, maternal education, utilization of antenatal care services, and anemia play important roles in the occurrence of CED among pregnant women. Among all variables analyzed, BMI was the most dominant factor associated with CED in this study.

DISCUSSION

The findings of this study indicate that maternal education, parity, BMI, ANC attendance, hemoglobin level, and iron tablet consumption were significantly associated with CED in the bivariate analysis. These associations may be explained through both biological and social mechanisms. Maternal education can influence health literacy, nutritional knowledge, food choices, and the ability to understand health messages delivered during antenatal care. Women with lower educational levels may have limited access to information regarding balanced nutrition, iron supplementation, and early recognition of nutritional problems during pregnancy.

This finding is in line with previous studies reporting that low maternal education is associated with poorer nutritional status among women, particularly in rural and low-resource settings.

Maternal Age

Based on the results of this study, most respondents in both groups were aged 20–35 years, comprising 118 women (34.9%) in the CED group and 126 women (37.3%) in the non-CED group. The analysis showed that maternal age was not significantly associated with the occurrence of CED among pregnant women ($p=0.331$). His finding aligns with several studies that have explored the determinants of CED in pregnant women, suggesting that while age is often considered a factor, it may not be as influential as other variables such as nutritional intake, parity, and health conditions. Several studies have shown that maternal age, particularly the age group of 20-35 years, is not significantly associated with CED. For instance, research conducted in the Lere Health Center and Bandar Lampung City found no significant relationship between maternal age and CED occurrence, with p -values of 0.197 and 1.000, respectively (Widyayanti et al., 2025; Sulistianingrum et al., 2024).

The lack of significant association between maternal age and CED in pregnant women may be partly explained by the complex interplay of confounding factors such as parity, socioeconomic status, nutritional knowledge, and pre-pregnancy nutritional status. Several studies indicate that maternal age alone is insufficient to predict CED risk without accounting for these variables, highlighting the multifactorial nature of maternal nutrition and its outcomes. Methodological considerations, including study design (cross-sectional vs. longitudinal), sample size, and statistical modeling approaches, critically influence the detection of associations between maternal age and CED. Small sample sizes and limited adjustment for confounders may lead to non-significant findings, underscoring the need for robust multivariate analyses and larger, well-powered studies (Irwana Wahab, 2024; Bodnar & Hutcheon, 2024).

Measurement timing and nutritional assessment tools, such as the use of mid-upper arm circumference (MUAC) versus body mass index (BMI), and the timing of nutritional status evaluation (preconception, trimester-specific), affect the sensitivity of detecting CED and its relationship with maternal age. This suggests that temporal and methodological heterogeneity contribute to inconsistent findings across studies (Rachmawati et al., 2019; Halimah et al., 2022; Workicho et al., 2020). Cultural and ecological factors, including food beliefs, household food insecurity, and seasonal variations in maternal intake and activity, modulate the maternal age-CED association by influencing dietary patterns and energy availability. These contextual factors introduce additional layers of complexity that theoretical models must incorporate to fully understand maternal nutrition dynamics (Nigatu et al., 2018; Mogi et al., 2024). The evidence challenges simplistic age-based risk models and supports a more nuanced, multilevel theoretical approach that integrates biological, socioeconomic, behavioral, and environmental determinants to explain maternal CED and its outcomes (Genowska et al., 2022; Olapeju et al., 2021).

Maternal Education

The results of this study suggest that the majority of pregnant women had a middle-level education (junior to senior high school), accounting for 36.7% in the CED group and 31.4% in the non-CED group. However, the study also found that pregnant women with lower educational levels (no formal education to elementary school) were still found among those experiencing CED. The chi-square test showed that maternal education was significantly associated with the occurrence of Chronic Energy Deficiency (CED) among pregnant women ($p=0.031$). Furthermore, multivariate analysis confirmed that maternal education remained a significant factor associated with CED ($OR=2.754$; $p=0.001$).

Education plays a crucial role in shaping maternal health behaviors, particularly in understanding and addressing nutritional needs during pregnancy. Women with higher education levels tend to have better health literacy, which enables them to comprehend the importance of nutrition, regular prenatal check-ups, and adherence to supplement regimens. Conversely, those with lower education levels often face challenges in accessing and understanding health information, which can lead to conditions like Chronic Energy Deficiency (CED). This disparity underscores the need for targeted educational interventions to improve maternal health

outcomes. Women with higher education levels generally exhibit better nutritional knowledge and practices. For instance, a study in Tehran found that women with university-level education had significantly higher nutritional knowledge scores compared to those with only primary education (Rajaeieh et al., 2026).

Pregnant women with lower education levels are more susceptible to CED due to inadequate nutritional knowledge and poor dietary practices. In South Kalimantan, a significant portion of pregnant women with CED had low nutritional knowledge and poor consumption patterns (Istiqomah et al., 2025). While higher education levels generally correlate with better maternal health knowledge and practices, it is essential to consider the broader context, including socioeconomic factors and cultural beliefs. For instance, even among educated women, cultural myths about nutrition during pregnancy can persist, influencing dietary behaviors (Reyna et al., 2020).

Kaumpungan, in his study, found that maternal education was significantly associated with CED, with a chi-square test result of $p=0.031$ and an odds ratio of 2.754 in multivariate analysis, indicating that lower educational levels increase the risk of CED among pregnant women. Education influences health literacy, enabling women to make informed decisions about nutrition and healthcare, which are crucial in preventing CED (Kaumpungan, Ilmiah, & Maulina, 2024).

Maternal Occupation

This study highlights that a significant proportion of pregnant women diagnosed with Chronic Energy Deficiency (CED) are not employed, with 46.4% being unemployed compared to only 3.6% who are employed. Conversely, among pregnant women without CED, 5.6% are employed, while 44.4% are not. Despite these figures, the study found no statistically significant correlation between CED and maternal occupation ($p=0.187$). This suggests that while employment status may appear to differ between those with and without CED, it is not a determining factor in the incidence of CED among pregnant women.

A study by Setiawati found no statistically significant correlation between CED and maternal occupation, with a p -value of 0.187, suggesting that employment status does not significantly influence the incidence of CED (Setiawati, & Puspitasari, 2024). CED in pregnant women is influenced by factors such as age, parity, energy and protein intake, and history of infectious diseases, rather than employment status. Pregnant women with CED often have insufficient energy intake but adequate protein intake, and most do not experience infectious diseases (Nasaru et al., 2023). Other studies have shown that demographic and behavioral characteristics, such as education level and income, can also play a role in the incidence of CED (Akbarini & Siswina, 2022). Employment during pregnancy has been associated with various pregnancy outcomes, but not necessarily with CED. Employed women generally have more favorable demographic and behavioral characteristics, such as higher education and income levels. The lack of a significant correlation between employment and CED suggests that other factors, such as nutritional intake and health status, are more critical in determining CED risk (Rocheleau et al, 2017).

Parity

Based on parity, primigravida mothers were more common in the CED group (26.9%), while multigravida mothers were more common in the non-CED group (37.9%) in this study. Chi-square test showed that parity ($p=0.000$) was significantly associated with the occurrence of CED. The relationship between parity and the occurrence of CED in pregnant women is a significant area of study, as evidenced by multiple research findings. Parity, which refers to the number of times a woman has given birth, has been shown to influence the nutritional status of pregnant women, thereby affecting the incidence of CED. The studies provided indicate a significant association between parity and CED, with primigravida mothers being more common in the CED group and multigravida mothers being more prevalent in the non-CED group. This suggests that parity is a critical factor in understanding and addressing CED among pregnant women.

Primigravida women may face unique challenges, including a lack of experience in managing nutritional needs, which can lead to insufficient iron intake. This highlights the

necessity for targeted nutritional interventions for first-time mothers to address their increased nutritional requirements and prevent anemia during pregnancy (Irawan et al., 2024). Multigravida women had a higher risk of having an inadequately diversified diet (AOR = 2.85) compared to primigravida women. This suggests that nutritional needs may differ, with multigravida women potentially facing challenges in maintaining dietary diversity. First-time mothers (primigravida) may encounter unique challenges, such as a lack of experience in meal planning and food preparation, which can impact their nutritional status (Mohammed et al., 2023). Research indicates that risk parity significantly impacts chronic energy deficiency (CED) in pregnant women, with a notable 43.3% of cases linked to this factor. While the study does not specifically differentiate between primigravida and multigravida groups, it highlights that nutritional needs and challenges may vary, with first-time mothers potentially facing greater difficulties in meeting these needs due to inexperience and lower family income, which was below the district minimum wage for 60% of respondents (Fibrila, Ridwan, & Herlina, 2023).

The findings underscore the importance of family planning and nutritional education as preventive measures against CED. Emphasizing the need for adequate nutritional intake before and during pregnancy, especially for primigravida and high-parity mothers, can help mitigate the risk of CED (Rachmi et al., 2024).

Body Mass Index

The distribution of BMI categories showed a clear difference between pregnant women with and without CED. Underweight BMI was more common among women with CED, whereas overweight and obese BMI categories were observed only among women without CED. The association between BMI and CED was statistically significant ($p < 0.001$). This finding indicates that the nutritional status of the mother prior to and during pregnancy exerts a significant influence on the development of CED. The results of the multivariable analysis conducted on the first to third steps indicate a p-value of 0.000 ($p \leq 0.05$) and an OR of 23.209 on the third step, suggesting a significant association between IMT in mothers and the occurrence of CED, with a 23.209-fold increased risk of developing CED.

Body Mass Index (BMI) is a critical factor influencing the nutritional status and health outcomes of pregnant women, particularly in the context of Chronic Energy Deficiency (CED). CED is a significant nutritional issue during pregnancy, affecting both maternal and fetal health. The relationship between maternal BMI and CED is evident, with underweight women being at a higher risk of developing CED, which can lead to adverse pregnancy outcomes. The multivariate analysis indicates that maternal BMI is a dominant factor in the incidence of CED, with a significantly increased risk for those with a BMI indicative of undernutrition. This highlights the importance of maintaining an adequate nutritional status before and during pregnancy to mitigate the risk of CED and its associated complications.

Study found that most CED pregnant women had a normal BMI (28.4%), while 21.6% were underweight, and none were obese, indicating a strong link between low BMI and CED incidence. The multivariate test results showed a significant relationship between maternal BMI and CED, with an odds ratio of 23.209, suggesting that women with low BMI are at a much higher risk of developing CED (Rachmi et al., 2024). Maternal BMI is a crucial determinant of pregnancy outcomes, including birth weight. Underweight women are more likely to have babies with low birth weight, while overweight and obese women face risks such as gestational diabetes and pre-eclampsia. A study in South Sulawesi reported a 13.8% prevalence of CED among pregnant women, with significant consequences such as anemia and low birth weight (Rachmi et al., 2024).

Several studies provide detailed insights into endocrine and metabolic alterations associated with abnormal BMI, such as disrupted insulin signaling, inflammatory cytokine elevation, and hypoxic placental environments, elucidating pathways contributing to CED (Shen et al., 2026). Evidence supports the effectiveness of integrated nutritional and health education programs in reducing CED prevalence, emphasizing the importance of sustained, community-engaged approaches embedded in primary care (Adila & Surahmi, 2025).

BMI was significantly associated with Chronic Energy Deficiency (CED) because it reflects maternal nutritional status and energy reserves before and during pregnancy. Pregnant women

with low or abnormal BMI are more likely to have insufficient energy and nutrient stores to meet the increased physiological demands of pregnancy. As pregnancy requires additional energy for fetal growth, placental development, maternal tissue expansion, and increased blood volume, women with inadequate baseline nutritional status are more vulnerable to CED. Therefore, BMI can serve as an important indicator for identifying pregnant women at risk of chronic undernutrition. Pregnant women with low BMI often have insufficient energy reserves, which are crucial for supporting the increased metabolic demands of pregnancy. This deficiency can lead to inadequate weight gain during pregnancy, further exacerbating the risk of CED. The study indicates that pregnant women with CED, often indicated by a low upper arm circumference, are at a higher risk of giving birth to low birth weight (LBW) babies. Low BMI can reflect inadequate energy stores, making mothers more susceptible to CED during pregnancy. This deficiency impacts fetal growth and development, leading to adverse outcomes such as LBW. Regular health checks and adequate nutrition are crucial for mitigating these risks during pregnancy (Indryani et al., 2019).

BMI showed the strongest association with CED in this study. This finding is biologically plausible because low or abnormal BMI reflects inadequate maternal nutritional reserves before or during pregnancy. Pregnant women with poor baseline nutritional status may have insufficient energy stores to meet the increased metabolic demands of pregnancy, including fetal growth, placental development, maternal tissue expansion, and increased blood volume. However, the very high odds ratio for BMI should be interpreted with caution. Although BMI and CED were measured as different indicators, both are related to maternal nutritional status. Sparse data, imbalance in BMI categories between the case and control groups, or conceptual overlap between BMI and CED as indicators of maternal undernutrition may also influence the high estimate. Therefore, the association between BMI and CED should not be interpreted as a direct causal relationship. Future studies with larger samples, more balanced BMI distributions, dietary assessment, and multicollinearity testing are recommended to confirm the stability of this association.

ANC Visits

Among pregnant women with CED, 31.4% had ≥ 6 ANC visits, while 18.6% had fewer than 6 visits. Among pregnant women without CED, 36.7% had ≥ 6 ANC visits, while 13.3% had fewer than 6 visits. The chi-square test showed that the frequency of Antenatal Care (ANC) visits ($p=0.036$) was significantly associated with the occurrence of CED. Pregnant women with inadequate ANC visits were nearly twice as likely to experience CED ($OR=1.925$; $p=0.041$).

The frequency of antenatal care (ANC) visits is crucial for monitoring the health of pregnant women and their fetuses, particularly in preventing conditions such as chronic energy deficiency (CED) and low birth weight (LBW). The World Health Organization (WHO) recommends a minimum of eight ANC visits, but in Indonesia, this has been adjusted to at least six visits to accommodate local healthcare capabilities. Research indicates that the frequency of ANC visits is significantly associated with the incidence of CED and other pregnancy complications, highlighting the importance of adhering to these guidelines. ANC visits are essential for early detection of pregnancy complications and influence the provision of nutritional education to prevent CED. Regular visits allow healthcare providers to monitor the nutritional status of the mother and fetus, which is crucial for preventing CED and ensuring healthy fetal development (Maolida, Nurhendriyana, & Nurbaniwati, 2021). ANC visits provide an opportunity for healthcare providers to educate pregnant women about the importance of balanced nutrition and supplementation. This education is crucial for preventing CED, which can lead to low birth weight and other complications (Hasanah et al., 2025). The World Health Organization recommends at least eight ANC visits to ensure comprehensive care, including nutritional education, risk-factor screening, and planning for delivery and the postpartum period (Mosebetsi, Rapinyana, & Kubanji, 2026).

Programs that focus on educating pregnant women about nutrition and the importance of ANC visits have shown significant improvements in maternal knowledge and health outcomes. For instance, community-based education initiatives have increased awareness and compliance with ANC visit schedules. Comprehensive ANC interventions that include both medical care and

educational components have been associated with reduced rates of maternal mortality, preterm births, and neonatal complications. These outcomes highlight the importance of integrating health education with medical care in ANC interventions. While the benefits of regular ANC visits are well-documented, challenges remain in ensuring access to high-quality ANC services, particularly in low-resource settings. Barriers such as limited healthcare infrastructure and socioeconomic challenges can hinder the effectiveness of ANC programs. Addressing these barriers through policy reforms and increased investment in healthcare systems is essential for optimizing maternal and neonatal health outcomes (Munthe & Sembiring, 2025).

The results of statistical tests in the study Nurana (2023) indicate that there is a significant association between the frequency of ANC visits and mothers' adherence to taking iron tablets. Insufficient intake of energy and essential nutrients, particularly iron, contributes to anemia, which in turn exacerbates CED. This cycle diminishes the body's capacity to deliver oxygen and nutrients to both maternal tissues and the developing fetus, highlighting the critical need for nutritional interventions to improve health outcomes for pregnant women (Retsanboy et al., 2025).

Hemoglobin Level

In this study, 24.6% of pregnant women with CED had anemia (Hb <11 g/dL), and 25.4% had normal Hb levels. Among pregnant women without CED, 11.8% had anemia and 38.2% had normal Hb levels. The chi-square test showed that hemoglobin level is significantly associated ($p=0.000$) with the occurrence of CED. Hemoglobin level was another important factor, with anemic mothers having a 2.5 times greater risk of CED compared to mothers with normal hemoglobin levels ($OR=2.527$; $p=0.003$).

Anemia during pregnancy is a significant health concern, closely linked to chronic energy deficiency (CED) and various pregnancy complications. A study by Antari and Nudhira (2021) shows that the p -value is 0.001 ($p<0.05$), which indicates that there is a significant association between anemia status and nutritional status in pregnant women in the third trimester, as measured by upper arm circumference. The prevalence of anemia among pregnant women is notably high, with significant implications for both maternal and neonatal health. Anemia, defined by hemoglobin levels below 11 g/dL, is associated with increased risks of low birth weight (LBW) in infants, preterm birth, and other complications. The relationship between anemia and CED is complex, with both conditions often co-occurring and exacerbating each other's effects (Retsanboy et al, 2025).

A few studies employ longitudinal designs and mixed-effects models to assess hemoglobin trajectories and their association with CED and pregnancy outcomes (Evanchuk et al, 2023; Xu et al, 2022), allowing for temporal dynamics and within-subject variability to be captured. This approach enhances understanding of how hemoglobin changes over pregnancy stages and influences outcomes. Studies often incorporate anthropometric measures (e.g., MUAC, LILA) alongside hemoglobin levels and assess the effects of dietary intake and supplementation on anemia and CED using regression analyses, providing a comprehensive view of nutritional status and its impact on anemia and CED. This multidimensional approach enriches interpretation (Adfar, 2023; Lestari & Saputro, 2022).

Anemia in pregnant women, characterized by hemoglobin levels below 11 g/dL, is a significant public health issue that can be exacerbated by chronic energy deficiency (CED) or malnutrition. The relationship between maternal nutritional status and hemoglobin levels is crucial, as inadequate intake of essential nutrients, particularly iron, can lead to anemia, which in turn can worsen CED by impairing the body's ability to distribute oxygen and nutrients effectively. This interplay between anemia and nutritional status during pregnancy is supported by various studies, highlighting the need for targeted health interventions. Several studies have established a significant relationship between poor nutritional status and the incidence of anemia in pregnant women. For instance, a study found that pregnant women with poor nutritional status are 1.672 times more likely to develop anemia compared to those with adequate nutrition. Insufficient intake of energy and essential nutrients, particularly iron, contributes to anemia, which in turn exacerbates CED. This cycle diminishes the body's capacity to deliver oxygen and nutrients to both maternal tissues and the developing fetus, highlighting the critical need for

nutritional interventions to improve health outcomes for pregnant women (Retsanboy et al., 2025; Aruan et al., 2025).

CED is a critical factor contributing to anemia. Research indicates that CED significantly correlates with anemia, particularly in the first trimester of pregnancy, with a correlation coefficient of 0.590, suggesting a close and positive relationship. Another study reported a strong correlation between abnormal nutritional status and anemia, with a significant positive relationship indicating that poor nutrition increases the risk of anemia (Krisnawati, Wardani, & Khasanah, 2025; Auliva, Puteri, & Mariati, 2024).

Iron Tablet Consumption

Most pregnant women with CED (43.2%) had taken ≥ 90 Iron tablets. However, a small proportion (6.8%) had not met the recommended Iron tablet intake, which could potentially increase the risk of anemia and CED. The chi-square test showed that iron tablet consumption is significantly associated ($p=0.030$) with the occurrence of CED. CED prevalence varied widely (11.3% to 36.5%) and was strongly associated with anemia and poor birth outcomes across studies (Mukkadas, Salma, & Cristian, 2021; Fitriah et al, 2023). Iron supplementation improved hemoglobin and ferritin levels significantly, especially in women with poor baseline status, and was linked to improved MUAC and other nutritional indicators. Nutritional knowledge, dietary intake adequacy, and ANC attendance were important determinants of maternal nutritional status and CED risk (Wati et al., 2024). Multiple studies establish a significant association between chronic energy deficiency and anemia during pregnancy, underscoring the intertwined nature of these conditions. Research highlights that poor nutritional status exacerbates anemia risk and adverse birth outcomes. The role of socioeconomic determinants, such as income and education, in influencing CED and anemia prevalence is also documented (Wati et al., 2024; Tarina, & Mutahar, 2023).

Husband's education and occupation

Most of the respondents' husbands in this study had a junior high or high school education, 31.1% among pregnant women with CED and 27.5% among pregnant women without CED. No significant association was found between CED and the husband's education ($p=0.311$) or the husband's occupation ($p=0.806$). Most husbands worked as laborers or farmers, 36.4% among pregnant women with CED and 37% among pregnant women without CED.

Evidence indicates that higher-status paternal occupations are linked to better maternal health service utilization and improved pregnancy outcomes, such as increased immunization coverage and reduced adverse birth events. Occupational status serves as a proxy for economic stability and access to resources, which are crucial for managing CED in pregnant women. Multiple studies report that lower paternal education and occupation status are associated with higher prevalence of maternal CED and related adverse outcomes, reflecting socioeconomic disparities (Alamgir, Ullah, & Hasan, 2024; Kaumpungan, Ilmiah, & Maulina, 2024). Household wealth and paternal education jointly influence maternal health service access and outcomes in CED contexts. Higher paternal education often corresponds to better household resource availability. The multidimensional nature of socioeconomic determinants in maternal and neonatal health highlights that paternal education and occupation significantly influence family socioeconomic status and maternal health outcomes, particularly in pregnancies complicated by Chronic Energy Deficiency (CED). This supports theories that paternal factors are integral to maternal and child health beyond maternal characteristics alone (Okyere, Hey, & Yaya, 2025; Shapiro, 2017).

The findings of this study should be interpreted through both biological and social pathways. Maternal education may influence CED through health literacy, nutritional knowledge, food choices, ANC utilization, and adherence to iron supplementation. Pregnant women with lower educational levels may have limited access to health information and may be less likely to understand the importance of balanced nutrition and regular antenatal care. Parity may also contribute to CED through different mechanisms. Primigravida women may have limited experience in managing nutritional needs during pregnancy.

In contrast, women with higher parity may experience increased household responsibilities, greater economic burden, and depletion of maternal nutritional reserves due to repeated pregnancies. BMI was the strongest determinant of CED, which is biologically plausible because low or abnormal BMI reflects inadequate maternal energy reserves before or during pregnancy. When pregnancy increases energy and nutrient requirements, women with poor baseline nutritional status are more vulnerable to chronic energy deficiency. Inadequate ANC attendance may further increase the risk of CED because ANC visits provide opportunities for nutritional screening, weight monitoring, hemoglobin examination, iron supplementation, and nutrition counseling. Similarly, low hemoglobin levels and inadequate iron tablet consumption may reflect poor diet quality, insufficient micronutrient intake, and increased risk of anemia, which can worsen maternal nutritional status.

Several limitations should be considered when interpreting the findings. First, this study used retrospective secondary data from maternal health records; therefore, the analysis depended on the completeness and accuracy of existing documentation. Important variables such as dietary intake, household income, food security, cultural food practices, and maternal nutritional knowledge could not be fully assessed. Second, because this was a case-control study using retrospective data, causal relationships cannot be established, and the findings should be interpreted as associations. Third, potential selection bias may have occurred because only pregnant women with complete maternal health records were included, while those with incomplete records were excluded. Finally, the very high odds ratio for BMI should be interpreted with caution. Although BMI is biologically related to CED, the high estimate may also be influenced by sparse data, imbalance in BMI categories between the case and control groups, or conceptual overlap between BMI and CED as indicators of maternal nutritional status. Therefore, future studies should include larger samples, more balanced BMI distributions, dietary assessment, and multicollinearity testing to confirm the stability of this association.

CONCLUSION

This study found that maternal education, parity, body mass index (BMI), frequency of antenatal care (ANC) visits, hemoglobin level, and iron tablet consumption were significantly associated with Chronic Energy Deficiency (CED) among pregnant women in the working area of Keruak Primary Health Center in 2024. In the final multivariate model, BMI showed the strongest association with CED, followed by maternal education, ANC attendance, and hemoglobin level. Pregnant women with abnormal or underweight BMI, lower educational background, inadequate ANC visits, and anemia had higher odds of experiencing CED compared with their respective reference groups. However, because this study used a case-control design, these findings should be interpreted as associations and not as causal relationships. Based on these findings, maternal nutritional screening and counseling should be strengthened before and during pregnancy. Health centers are encouraged to conduct early screening using MUAC and BMI, provide individualized nutrition counseling, and offer targeted supplementary feeding for pregnant women with low MUAC, low BMI, or inadequate weight gain. Preconception care should also be improved by screening women of reproductive age for nutritional status and anemia before pregnancy, followed by counseling on a balanced diet, iron-folic acid supplementation, and healthy pregnancy planning.

Strategies to improve ANC utilization are also needed, including active follow-up by midwives and community health workers, reminder systems for scheduled ANC visits, family involvement, and improved accessibility of maternal health services. During ANC visits, healthcare workers should ensure regular weight monitoring, MUAC assessment, hemoglobin examination, nutrition education, and iron-folic acid supplementation counseling. Anemia prevention should be strengthened through routine hemoglobin screening, monitoring of iron tablet adherence, education on iron-rich foods and vitamin C intake, and early management of pregnant women with low hemoglobin levels. Future studies are recommended to include dietary intake, household income, food security, cultural food practices, and prospective data collection to understand better the pathways linking maternal nutritional status and CED.

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