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Analysis of Factors Associated With the Occurrence of Preeclampsia in Pregnant Women in the Mawar Ward of Dr. H. Soewondo General Hospital Kendal

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Abstract

Preeclampsia remains a major maternal health concern requiring early identification of interacting clinical and contextual risk factors. This cross-sectional study examined factors associated with preeclampsia among 83 pregnant women treated in the Mawar Ward of Dr. H. Soewondo General Hospital, Kendal. The independent variables were maternal age, previous preeclampsia, family medical history, obesity, interpregnancy interval, knowledge and attitudes, education, and socioeconomic status. Data were analyzed using univariate, Chi-square, and multivariable logistic regression procedures. All eight factors were significantly associated with preeclampsia severity ($p = 0.001$). Interpregnancy interval showed the largest Chi-square value (83.000), followed by knowledge and attitudes (79.039) and maternal age (75.242). The overall model was significant (Omnibus Chi-square = 114.085; $p = 0.001$), with Cox and Snell $R^2 = 0.747$ and Nagelkerke $R^2 = 1.000$. However, perfect separation occurred, making Exp(B) estimates unsuitable for identifying a definitive dominant factor. Comprehensive antenatal screening, maternal education, and timely referral are therefore essential for preventing progression to severe preeclampsia. Future studies should use larger, more heterogeneous samples and analytical methods robust to separation to obtain more reliable estimates of independent effects.

Keywords: *preeclampsia, maternal risk factors, interpregnancy interval, antenatal care, pregnancy.*

INTRODUCTION

Preeclampsia remains one of the most consequential hypertensive disorders of pregnancy and continues to contribute substantially to maternal and perinatal morbidity and mortality worldwide. Globally, preeclampsia is estimated to affect approximately 3–8% of pregnancies, while hypertensive disorders of pregnancy remain an important contributor to preventable maternal deaths (World Health Organization [WHO], 2025). Clinically, preeclampsia is characterized by new-onset hypertension after 20 weeks of gestation and may be accompanied by proteinuria or evidence of maternal organ dysfunction (Ives et al., 2020; Jung et al., 2022). Without timely recognition and appropriate management, the condition may progress to eclampsia, HELLP syndrome, pulmonary edema, acute kidney injury, hepatic dysfunction, stroke, fetal compromise, and maternal death (Bernolian et al., 2023; Katsi et al., 2024).

The burden of preeclampsia is particularly relevant in Indonesia, where hypertensive disorders of pregnancy remain among the major causes of maternal mortality alongside hemorrhage and other obstetric complications (Kementerian Kesehatan Republik Indonesia, 2024). A similar pattern is observed in Central Java, where pregnancy-related hypertension continues to contribute to maternal deaths despite broader improvements in maternal health services (Dinas Kesehatan Provinsi Jawa Tengah, 2024). In Kendal Regency, 22 maternal deaths were recorded in 2024, placing the regency among areas with a relatively high maternal mortality burden in the province, with hypertensive disorders of pregnancy identified among the contributing causes. These conditions indicate that strengthening risk identification, antenatal surveillance, and timely referral for women susceptible to preeclampsia remains an important maternal health priority at both regional and hospital levels.

The development of preeclampsia involves complex and interrelated biological mechanisms rather than a single causal pathway. Abnormal placentation, impaired remodeling of the spiral arteries, endothelial dysfunction, systemic inflammation, oxidative stress, and an imbalance in

angiogenic factors have been recognized as major mechanisms involved in its pathogenesis (Jung et al., 2022). These pathophysiological disturbances may subsequently produce widespread vascular dysfunction and reduced perfusion of multiple maternal organs, thereby explaining the heterogeneous clinical manifestations of the disorder (Ives et al., 2020). Consequently, contemporary approaches to preeclampsia emphasize the importance of identifying multiple maternal, obstetric, metabolic, and contextual factors that may collectively increase an individual woman's risk.

Maternal and obstetric characteristics represent an important group of factors associated with the occurrence and severity of preeclampsia. Maternal age outside the optimal reproductive range, previous preeclampsia, family history of hypertensive disorders, obesity, and abnormal interpregnancy intervals have been repeatedly associated with an increased risk of hypertensive complications during pregnancy (Amalina et al., 2022; Latipah et al., 2023; Martanti et al., 2024). Obesity may contribute to preeclampsia through metabolic dysfunction, chronic low-grade inflammation, insulin resistance, and endothelial impairment, whereas a previous history of preeclampsia may indicate persistent biological susceptibility in subsequent pregnancies (Parantika et al., 2021). Interpregnancy interval also warrants attention because excessively short or prolonged intervals may interact with maternal nutritional recovery, reproductive adaptation, and advancing maternal age, thereby modifying the risk profile of subsequent pregnancies (Martanti et al., 2024).

Beyond biological and obstetric determinants, behavioral and socioeconomic characteristics may influence the timely recognition and prevention of complications related to preeclampsia. Maternal knowledge and attitudes toward pregnancy complications can affect health-seeking behavior, adherence to antenatal recommendations, recognition of warning signs, and willingness to seek emergency care when symptoms develop (Setyaningsih et al., 2023). Educational attainment may further influence the ability to access, interpret, and apply health information, while socioeconomic circumstances may affect transportation, nutritional adequacy, continuity of antenatal care, and access to referral services. These determinants should therefore not be interpreted merely as background characteristics but as contextual factors that may interact with maternal and obstetric risks throughout pregnancy (Daeli et al., 2023; Sari et al., 2023).

Antenatal care provides a critical opportunity to identify women at increased risk of preeclampsia before severe clinical manifestations occur. Regular assessment of blood pressure, maternal weight, obstetric history, comorbid conditions, and warning symptoms enables health professionals to recognize potential complications and initiate timely follow-up or referral (Daeli et al., 2023). Nurses and other maternal health professionals also play an essential role in providing education, monitoring clinical deterioration, supporting adherence to preventive measures, and collaborating in the management of severe preeclampsia and eclampsia (Katsi et al., 2024; Setyaningsih et al., 2023). Effective prevention therefore requires an integrated approach that combines clinical screening with health education and systematic assessment of maternal, obstetric, and social risk factors.

The relevance of these factors is evident at Dr. H. Soewondo General Hospital, Kendal, where preeclampsia continues to represent a notable clinical burden. Preliminary hospital data from 2025 documented 1,914 obstetric patients, of whom 105 were diagnosed with preeclampsia, including a considerable proportion who presented with severe disease requiring intensive management. Clinical observations further indicated the presence of several potential risk characteristics among affected women, including chronic hypertension, previous preeclampsia, maternal age above 35 years, obesity, prolonged interpregnancy intervals, and inadequate antenatal care attendance. The continued presentation of women with severe preeclampsia suggests that identifying factors associated with disease severity within this specific hospital population may provide clinically relevant evidence for strengthening early detection and targeted antenatal surveillance.

Despite the recognized multifactorial nature of preeclampsia, evidence examining maternal, obstetric, behavioral, educational, and socioeconomic factors simultaneously remains limited in the specific context of Dr. H. Soewondo General Hospital, Kendal. Previous studies have frequently evaluated selected determinants independently, whereas a comprehensive assessment of several interrelated factors may provide a clearer understanding of the characteristics associated with preeclampsia in a local clinical population (Amalina et al., 2022; Sari et al., 2023). Accordingly, this study examines maternal age, previous history of preeclampsia, family medical history, obesity, interpregnancy interval, knowledge and attitudes, educational level, and socioeconomic status among

pregnant women treated in the Mawar Ward of Dr. H. Soewondo General Hospital, Kendal. The study aims to determine the association between these factors and the occurrence of preeclampsia and to identify the variables that make the greatest statistical contribution to the observed pattern of preeclampsia in this population.

RESEARCH METHODS

This study employed a quantitative analytical approach with a cross-sectional design to examine factors associated with preeclampsia among pregnant women treated in the Mawar Ward of Dr. H. Soewondo General Hospital, Kendal. The study was conducted from June to July 2026 and included 83 pregnant women who met the predetermined inclusion and exclusion criteria. The independent variables comprised maternal age, previous history of preeclampsia, family medical history, obesity, interpregnancy interval, knowledge and attitudes, educational level, and socioeconomic status, while the dependent variable was the occurrence of preeclampsia. Data were collected using structured questionnaires and patients' medical records to obtain information on sociodemographic characteristics, maternal and obstetric history, health-related knowledge and attitudes, and clinical conditions relevant to preeclampsia.

Data analysis was performed using univariate, bivariate, and multivariate statistical procedures. Univariate analysis was used to describe the frequency distribution and proportion of each study variable, whereas bivariate analysis was conducted using the Chi-square test to determine the association between each independent variable and preeclampsia, with statistical significance set at $p < 0.05$. Variables were subsequently examined simultaneously using binary logistic regression with the Backward Stepwise (Likelihood Ratio) method to assess their statistical contribution to the occurrence of preeclampsia. Model performance was evaluated using the Omnibus Test of Model Coefficients, Cox and Snell R Square, Nagelkerke R Square, and the Hosmer–Lemeshow goodness-of-fit test, while regression estimates were interpreted cautiously in the presence of complete or quasi-complete separation.

RESULTS AND DISCUSSION

Maternal and Obstetric Factors Associated with Preeclampsia

Among the 83 pregnant women included in the study, 46 respondents (55.4%) were classified as having mild preeclampsia (PER), whereas 37 respondents (44.6%) had severe preeclampsia (PEB). The descriptive profile showed that 48 respondents (57.8%) were in the non-risk maternal age category of 20–35 years, while 35 respondents (42.2%) were categorized as being at risk because they were younger than 20 years or older than 35 years. In addition, 54 respondents (65.1%) had no previous history of preeclampsia, 50 (60.2%) reported no family history of disease, 53 (63.9%) were classified as not being at risk of obesity, and 46 (55.4%) had an interpregnancy interval of 2–5 years. Although the majority of respondents were distributed within the categories conventionally regarded as lower risk, the proportion of severe preeclampsia remained substantial, indicating that preeclampsia should be understood as a multifactorial condition rather than as the consequence of a single maternal characteristic (Amalina et al., 2022; Ives et al., 2020; Jung et al., 2022).

Maternal age showed a statistically significant association with the severity of preeclampsia ($p = 0.001$). Of the 48 women in the non-risk age category, 46 experienced mild preeclampsia and only two experienced severe preeclampsia, whereas all 35 women in the risk-age category experienced severe preeclampsia. This marked distribution supports the clinical relevance of maternal age in evaluating hypertensive complications during pregnancy, particularly because pregnancies at the extremes of reproductive age may be accompanied by less favorable cardiovascular, metabolic, and vascular adaptations. Latipah et al. (2023) similarly identified maternal age as a factor associated with preeclampsia, while Luger and Kight (2022) emphasized that maternal characteristics should be incorporated into the assessment of hypertension during pregnancy. The present findings therefore indicate that maternal age should remain a fundamental component of early risk stratification, although the cross-sectional design does not permit causal inference.

A previous history of preeclampsia was also strongly associated with the observed severity of the condition ($p = 0.001$). Among 54 respondents without a previous history of preeclampsia, 46 had mild preeclampsia and eight had severe preeclampsia, whereas all 29 respondents with a history of preeclampsia experienced severe preeclampsia. This pattern suggests that previous preeclampsia

identifies a particularly vulnerable group whose subsequent pregnancies require closer surveillance. Previous hypertensive pregnancy disorders may reflect persistent maternal vascular, metabolic, immunological, or placental susceptibility that can re-emerge during a subsequent pregnancy (Ives et al., 2020; Jung et al., 2022). The finding is also consistent with Parantika et al. (2021), who reported an association between previous preeclampsia and subsequent preeclampsia, reinforcing the importance of comprehensive obstetric history-taking during antenatal assessment.

Family medical history demonstrated another significant relationship with preeclampsia severity ($p = 0.001$). Of the 50 respondents without a family history of disease, 46 experienced mild preeclampsia and four experienced severe preeclampsia, whereas all 33 respondents who reported a family history of disease were classified as having severe preeclampsia. Familial clustering may reflect a combination of genetic susceptibility, shared cardiometabolic characteristics, environmental exposures, and health-related behaviors that influence maternal vascular responses during pregnancy. Jung et al. (2022) described preeclampsia as a heterogeneous syndrome involving complex interactions among maternal predisposition, placental abnormalities, immune mechanisms, and vascular dysfunction, while Yang and Wu (2022) further demonstrated the relevance of interacting metabolic and pregnancy-related factors in preeclamptic disorders. The present distribution therefore supports the inclusion of detailed family medical history in routine risk assessment rather than limiting screening exclusively to the woman's previous obstetric history.

Obesity was significantly associated with preeclampsia severity in this population ($p = 0.001$). Among the 53 respondents categorized as not being at risk of obesity, 46 experienced mild preeclampsia and seven experienced severe preeclampsia, while all 30 respondents in the obesity-risk category experienced severe preeclampsia. This result is biologically plausible because obesity is associated with chronic low-grade inflammation, insulin resistance, oxidative stress, endothelial dysfunction, and altered cardiovascular regulation, all of which can interact with placental abnormalities involved in preeclampsia (Ives et al., 2020; Jung et al., 2022). Amdadi et al. (2020) also demonstrated the relevance of body mass index and hemodynamic characteristics to preeclampsia, while Parantika et al. (2021) identified obesity as an important factor associated with the disorder. Consequently, assessment of maternal nutritional status should be integrated with blood-pressure monitoring and obstetric history when screening for high-risk pregnancies.

Table 1. Maternal and obstetric factors according to preeclampsia severity among pregnant women in the Mawar Ward of Dr. H. Soewondo General Hospital, Kendal (n = 83)

Factor	Category	Mild preeclampsia, n	Severe preeclampsia, n	Total, n (%)	p-value
Maternal age	Non-risk (20–35 years)	46	2	48 (57.8)	0.001
	Risk (<20 or >35 years)	0	35	35 (42.2)	
Previous preeclampsia	No previous history	46	8	54 (65.1)	0.001
	Previous history	0	29	29 (34.9)	
Family medical history	No family history	46	4	50 (60.2)	0.001
	Family history present	0	33	33 (39.8)	
Obesity	Non-risk	46	7	53 (63.9)	0.001
	At risk/obese	0	30	30 (36.1)	
Interpregnancy interval	Non-risk (2–5 years)	46	0	46 (55.4)	0.001
	Risk (<2 or >5 years)	0	37	37 (44.6)	
Total preeclampsia severity		**46 (55.4%)**	**37 (44.6%)**	**83 (100%)**	

The strongest separation between the two preeclampsia categories was observed for interpregnancy interval. All 46 women with a non-risk interpregnancy interval of 2–5 years experienced mild preeclampsia, whereas all 37 women with a risk interval of less than two years or more than five years experienced severe preeclampsia, resulting in a statistically significant association ($p = 0.001$). This finding is particularly important because interpregnancy interval represents a reproductive characteristic that can be identified before or early in a subsequent pregnancy and may therefore contribute to anticipatory risk assessment. Martanti et al. (2024) similarly reported an association between pregnancy spacing and preeclampsia and emphasized the combined importance of pregnancy interval and obesity in determining maternal risk. The present findings extend this observation by showing a complete separation of severity categories according to interpregnancy interval within the study sample, although this unusually strong pattern requires cautious statistical interpretation.

The associations observed for maternal age, obstetric history, family history, obesity, and pregnancy spacing support the broader understanding that preeclampsia arises from interactions between maternal susceptibility and pregnancy-specific pathophysiological processes. Abnormal placentation and inadequate spiral artery remodeling can lead to placental hypoperfusion and the release of antiangiogenic, inflammatory, and oxidative mediators into the maternal circulation, eventually producing systemic endothelial dysfunction (Jung et al., 2022). Maternal conditions such as chronic hypertension and cardiometabolic dysfunction may reduce physiological reserve and intensify these mechanisms, thereby increasing vulnerability to more severe manifestations of the disease (Battarbee et al., 2020; Ives et al., 2020). The significant associations found in this study are therefore clinically coherent with the contemporary concept of preeclampsia as a heterogeneous syndrome in which underlying maternal factors modify the response to placental dysfunction. Such an interpretation is preferable to viewing any single variable as an isolated etiological determinant.

The findings are also comparable with evidence from Indonesian clinical populations demonstrating that preeclampsia is associated with multiple maternal and pregnancy-related characteristics. Mariati et al. (2022) reported several factors associated with preeclampsia among women in the third trimester, while Sari et al. (2023) similarly identified multiple characteristics associated with preeclampsia among pregnant women receiving hospital care. Nevin et al. (2025) further demonstrated that contemporary hospital-based cases of preeclampsia remain linked to a combination of maternal risk characteristics rather than a single explanatory variable. These studies reinforce the interpretation of the present results, particularly because substantial proportions of women with severe preeclampsia were observed among those with risk-age characteristics, previous preeclampsia, family medical history, obesity, and abnormal pregnancy spacing. Nevertheless, differences in population characteristics, definitions of exposure categories, referral patterns, and clinical severity should be considered when comparing effect patterns across studies.

From a clinical perspective, the results underscore the importance of systematic antenatal screening beginning with variables that can be obtained rapidly from history-taking and basic clinical assessment. Maternal age, previous preeclampsia, family medical history, obesity, and interpregnancy interval can all be identified without complex diagnostic technology, allowing high-risk women to be recognized early and monitored more intensively. Current understanding of hypertension in pregnancy emphasizes repeated blood-pressure assessment, evaluation of symptoms and organ dysfunction, and timely management when clinical deterioration occurs (Karrar et al., 2024; Luger & Kight, 2022). In severe cases, rapid recognition is crucial because preeclampsia can progress to eclampsia, HELLP syndrome, pulmonary edema, neurological complications, and other life-threatening conditions (Bernolian et al., 2023; Katsi et al., 2024). Maternal risk assessment should therefore function as an entry point for enhanced surveillance rather than as a substitute for continued clinical evaluation throughout pregnancy.

Preventive strategies should additionally address modifiable factors before and during pregnancy while recognizing that not all preeclampsia determinants can be altered. Optimization of maternal nutritional status, appropriate pregnancy planning, management of chronic hypertension, and adherence to antenatal monitoring may reduce avoidable components of maternal risk, while selected preventive nutritional interventions have also been examined in relation to preeclampsia prevention (Kaldygulova et al., 2023; Tiara Deka et al., 2022). Women with previous preeclampsia or other non-modifiable risk factors require particular attention because risk reduction depends principally on early

recognition, surveillance, and timely clinical intervention rather than removal of the underlying predisposition. The significant patterns observed in the Mawar Ward therefore provide practical support for combining preconception counseling, antenatal risk stratification, maternal weight assessment, and careful obstetric history-taking. Such an integrated approach is consistent with the need to prevent progression from an initially manageable hypertensive disorder to severe maternal and fetal complications.

complete concentration of severe preeclampsia among several risk categories particularly the 35 women in the risk-age group, 29 women with previous preeclampsia, 33 women with a family medical history, 30 women at risk of obesity, and 37 women with risk interpregnancy intervals—produced exceptionally strong statistical separation between exposure categories and preeclampsia severity. Although all five variables showed statistically significant Chi-square results at $p = 0.001$, these associations do not by themselves establish causality because the study used a cross-sectional design and involved a hospital-based sample of 83 respondents. Preeclampsia remains a complex clinical syndrome whose expression is influenced by vascular, metabolic, placental, obstetric, and contextual mechanisms (Amalina et al., 2022; Ives et al., 2020; Jung et al., 2022).

Knowledge, Attitudes, Education, and Socioeconomic Factors Associated with Preeclampsia

Behavioral and socioeconomic characteristics demonstrated substantial differences according to preeclampsia severity among the 83 respondents. In the descriptive analysis, 47 women (56.6%) were classified as having positive knowledge and attitudes, whereas 36 (43.4%) were classified as having negative knowledge and attitudes. Educational characteristics initially consisted of 16 respondents (19.3%) with low education, 49 (59.0%) with secondary education, and 18 (21.7%) with higher education, while socioeconomic status was categorized as adequate among 48 respondents (57.8%) and inadequate among 35 respondents (42.2%). These characteristics are important because behavioral, educational, and socioeconomic circumstances may influence how pregnant women interpret health information, utilize antenatal services, recognize danger signs, and respond to pregnancy-related complications (Notoatmodjo, 2014; Priyoto, 2019).

Knowledge and attitudes showed a statistically significant association with preeclampsia severity ($p = 0.001$). Of the 47 respondents with positive knowledge and attitudes, 46 experienced mild preeclampsia and only one experienced severe preeclampsia, whereas all 36 women classified as having negative knowledge and attitudes experienced severe preeclampsia. This pronounced distribution indicates that maternal knowledge and attitudes were closely related to the observed severity pattern in this hospital-based sample. Knowledge can influence an individual's ability to recognize risk factors and warning signs, while attitudes shape readiness to engage in preventive behavior, follow professional recommendations, and seek health services when necessary (Notoatmodjo, 2014; Priyoto, 2019). Nevertheless, because the study was cross-sectional, the observed association should not be interpreted as evidence that inadequate knowledge or negative attitudes directly caused severe preeclampsia.

The relationship between knowledge, attitudes, and preeclampsia is clinically plausible because the development of severe disease may be influenced by delays in risk recognition and health-care utilization. Pregnant women who understand the significance of persistent headache, visual disturbances, epigastric pain, edema, elevated blood pressure, and other warning signs may be more likely to seek assessment before severe complications develop. Setyaningsih et al. (2023) demonstrated that health education concerning preeclampsia screening can improve skills in identifying pregnant women at high risk, emphasizing the importance of structured educational interventions. Similarly, Daeli et al. (2023) reported an association between antenatal care attendance and preeclampsia, suggesting that continuity of antenatal contact may facilitate both risk detection and maternal health education. These findings support the integration of preeclampsia education into routine antenatal encounters rather than limiting education to women who have already developed hypertensive complications.

Educational attainment was also significantly associated with preeclampsia severity ($p = 0.001$), although the direction of the distribution requires careful interpretation. For the bivariate analysis, the original dataset grouped 65 respondents into the lower educational category, of whom 46 experienced mild preeclampsia and 19 experienced severe preeclampsia, while all 18 respondents in the higher educational category experienced severe preeclampsia. This finding differs from the simple

expectation that higher formal education should always correspond to more favorable maternal outcomes. Formal education may improve access to and comprehension of health information, but it does not independently eliminate biological, obstetric, metabolic, or familial susceptibility to preeclampsia. Therefore, the significant association observed in this sample should be interpreted as a characteristic of the study population rather than as evidence that higher education increases the biological risk of severe preeclampsia.

Table 2. Behavioral, educational, and socioeconomic factors according to preeclampsia severity among pregnant women in the Mawar Ward of Dr. H. Soewondo General Hospital, Kendal (n = 83)

Factor	Category	Mild preeclampsia, n	Severe preeclampsia, n	Total, n (%)	p-value
Knowledge and attitudes	Positive	46	1	47 (56.6)	0.001
	Negative	0	36	36 (43.4)	
Education*	Lower educational category	46	19	65 (78.3)	0.001
	Higher educational category	0	18	18 (21.7)	
Socioeconomic status	Inadequate	35	0	35 (42.2)	0.001
	Adequate	11	37	48 (57.8)	
Total preeclampsia severity		**46 (55.4%)**	**37 (44.6%)**	**83 (100%)**	

The educational finding illustrates why health literacy and formal educational attainment should not be treated as interchangeable constructs. A woman with secondary or higher formal education may still have limited knowledge of preeclampsia if information regarding hypertensive disorders of pregnancy has not been adequately communicated during antenatal care. Conversely, women with fewer years of formal education may demonstrate strong pregnancy-related knowledge when counseling is delivered effectively and repeatedly through accessible health services. Notoatmodjo (2014) conceptualized health knowledge as an important determinant of health behavior, while Setyaningsih et al. (2023) showed that targeted health education can strengthen the ability to detect high-risk pregnancy conditions. These considerations indicate that antenatal counseling should be tailored to individual comprehension rather than assuming that educational credentials alone reflect preparedness to recognize preeclampsia.

Socioeconomic status also demonstrated a statistically significant relationship with preeclampsia severity ($p = 0.001$), but the pattern was not in the conventionally expected direction. All 35 respondents in the inadequate socioeconomic category experienced mild preeclampsia, whereas among the 48 respondents categorized as having adequate socioeconomic status, 11 experienced mild preeclampsia and 37 experienced severe preeclampsia. This distribution clearly indicates an association within the dataset, but it does not justify the conclusion that adequate socioeconomic status increases the causal risk of severe preeclampsia. Socioeconomic characteristics may be correlated with referral patterns, health-care-seeking behavior, maternal age, previous disease, obesity, reproductive history, and other variables that were simultaneously present in this sample. The finding therefore illustrates the importance of distinguishing statistical association from causal interpretation, particularly in relatively small hospital-based cross-sectional datasets.

Socioeconomic conditions remain clinically relevant because they can influence access to transportation, nutritional resources, antenatal examinations, laboratory testing, referral facilities, and continuity of maternal health care. Indonesian maternal health policy continues to emphasize the importance of accessible antenatal and referral services for preventing maternal complications, including hypertensive disorders of pregnancy (Kementerian Kesehatan Republik Indonesia, 2024).

Regional health data also demonstrate that pregnancy-related hypertension remains relevant to maternal mortality in Central Java, highlighting the need for equitable access to early detection and appropriate treatment regardless of household economic status (Dinas Kesehatan Provinsi Jawa Tengah, 2025). Daeli et al. (2023) further emphasized the relevance of antenatal attendance to preeclampsia, supporting the principle that contact with maternal health services may mediate part of the relationship between socioeconomic circumstances and pregnancy outcomes. Socioeconomic assessment should therefore be used to identify possible barriers to care rather than as a standalone biological predictor of preeclampsia.

The combined findings for knowledge, attitudes, education, and socioeconomic status suggest that the social dimensions of preeclampsia operate primarily through interaction with clinical and obstetric determinants. Preeclampsia develops through placental, vascular, inflammatory, and metabolic pathways, meaning that social characteristics do not directly replace the underlying biological mechanisms of disease (Ives et al., 2020; Jung et al., 2022). Instead, behavioral and socioeconomic factors may influence when risk is detected, how consistently antenatal services are used, whether preventive recommendations are followed, and how rapidly women seek care following the onset of symptoms. This interpretation is particularly important in the present study because several categories showed almost complete separation between mild and severe disease. Accordingly, behavioral and socioeconomic findings should be interpreted alongside maternal age, previous preeclampsia, family history, obesity, and interpregnancy interval rather than independently.

The results have direct implications for nursing and antenatal practice in the Mawar Ward and related maternal health services. Health professionals should assess not only blood pressure and obstetric history but also the woman's understanding of preeclampsia, perception of pregnancy-related danger signs, adherence to antenatal visits, and potential socioeconomic barriers to care. Structured counseling can include recognition of warning symptoms, the importance of regular blood-pressure monitoring, adherence to prescribed therapy, nutritional recommendations, and clear instructions regarding when emergency assessment is required. The Indonesian Society of Hypertension guidelines emphasize appropriate management of hypertension during the peripartum period, while Katsi et al. (2024) highlight the need for prompt diagnosis and treatment when preeclampsia progresses to eclampsia or severe complications (Budayasa et al., 2025; Katsi et al., 2024). Educational interventions should therefore be incorporated into clinical surveillance rather than considered an optional component of maternal care.

Another important implication concerns the interpretation of the unexpectedly high proportion of severe preeclampsia among respondents with higher education and adequate socioeconomic status. These results indicate that women who appear socially advantaged should not automatically be classified as clinically low risk, because biological and obstetric susceptibility may remain substantial despite favorable social characteristics. Severe preeclampsia can develop even in women who have greater access to information and resources, particularly when they also possess maternal risk factors such as advanced age, previous preeclampsia, chronic hypertension, obesity, or abnormal pregnancy spacing (Battarbee et al., 2020; Amalina et al., 2022). Consequently, risk assessment should combine social and behavioral information with objective clinical indicators and obstetric history. Universal vigilance is preferable to selective surveillance based solely on educational or socioeconomic assumptions.

Knowledge and attitudes, educational level, and socioeconomic status were significantly associated with preeclampsia severity in the study population, with each Chi-square analysis yielding $p = 0.001$. The strongest descriptive contrast was observed for knowledge and attitudes, because 46 of 47 respondents with positive characteristics had mild preeclampsia, while all 36 respondents with negative knowledge and attitudes had severe disease. However, the patterns for education and socioeconomic status caution against simplistic causal interpretation, since all women in the higher education category and most women with adequate socioeconomic status experienced severe preeclampsia within this particular sample. These findings reinforce the need for integrated antenatal assessment that combines maternal education and behavioral counseling with systematic evaluation of biological and obstetric risk factors.

Multivariable Analysis and Integrated Interpretation of Factors Associated with Preeclampsia

The multivariable analysis demonstrated that maternal age, previous history of preeclampsia, family medical history, obesity, interpregnancy interval, knowledge and attitudes, education, and socioeconomic status were simultaneously associated with preeclampsia severity among the 83 respondents. All variables included in the logistic regression model yielded $p = 0.001$, indicating statistically significant relationships within the observed dataset. These findings reinforce the multidimensional nature of preeclampsia, in which maternal, reproductive, metabolic, behavioral, and socioeconomic characteristics may coexist and interact within the same pregnancy. This interpretation is consistent with contemporary evidence describing preeclampsia as a heterogeneous syndrome involving placental dysfunction, vascular maladaptation, inflammatory processes, metabolic abnormalities, and maternal susceptibility rather than a disorder attributable to a single determinant (Ives et al., 2020; Jung et al., 2022).

Among the variables examined, interpregnancy interval produced the largest Chi-Square value at 83.000, followed by knowledge and attitudes at 79.039 and maternal age at 75.242. Family medical history yielded a Chi-Square value of 68.105, obesity 58.409, previous preeclampsia 55.416, socioeconomic status 48.680, and education 28.575. The relatively large statistical contribution of interpregnancy interval is consistent with the bivariate finding in which all 46 women with a non-risk interval experienced mild preeclampsia and all 37 women with a risk interval experienced severe preeclampsia. Martanti et al. (2024) similarly reported an association between pregnancy spacing and severe preeclampsia, supporting the relevance of reproductive interval as an important characteristic in pregnancy risk assessment.

The prominent statistical contribution of knowledge and attitudes also deserves careful clinical interpretation. Positive knowledge and attitudes were observed in 47 respondents, of whom 46 had mild preeclampsia and only one had severe disease, whereas all 36 respondents with negative knowledge and attitudes experienced severe preeclampsia. This pattern suggests that maternal understanding and health-related attitudes may be closely linked to early recognition of symptoms, compliance with antenatal recommendations, and timely utilization of health services, although the study design cannot establish the temporal direction of this relationship. Health education and screening interventions have been shown to improve recognition of high-risk pregnancies, indicating that knowledge should remain an integral component of preeclampsia prevention and early detection strategies (Setyaningsih et al., 2023).

Maternal age ranked third according to the Chi-Square statistic, with a value of 75.242, further emphasizing the relevance of reproductive age to preeclampsia severity. In this study, 46 of 48 women aged 20–35 years experienced mild preeclampsia, while all 35 respondents categorized as being younger than 20 or older than 35 years experienced severe preeclampsia. Age-related differences in cardiovascular adaptation, vascular integrity, metabolic function, and the prevalence of underlying chronic conditions may contribute to variations in susceptibility to hypertensive disorders of pregnancy (Battarbee et al., 2020; Latipah et al., 2023). Accordingly, maternal age remains a practical and readily identifiable variable for initial antenatal risk stratification.

Previous preeclampsia, family medical history, and obesity also contributed substantially to the multivariable model, with Chi-Square values of 55.416, 68.105, and 58.409, respectively. These variables represent different but potentially interconnected dimensions of biological vulnerability, including recurrent obstetric risk, familial or genetic susceptibility, and metabolic dysfunction. Parantika et al. (2021) identified previous preeclampsia and obesity as important factors associated with the disorder, while Amdadi et al. (2020) further demonstrated the relevance of maternal body mass index and hemodynamic characteristics. Such findings support a cumulative-risk perspective in which women presenting with multiple maternal or obstetric vulnerabilities require more intensive surveillance than those assessed on the basis of a single factor.

Table 3. Multivariable logistic regression and model-fit statistics for factors associated with preeclampsia severity (n = 83)

Variable / Model Statistic	Chi-Square / Value	df	p-value
Maternal age	75.242	1	0.001
Previous preeclampsia	55.416	1	0.001
Family medical history	68.105	1	0.001
Obesity	58.409	1	0.001
Interpregnancy interval	83.000	1	0.001
Knowledge and attitudes	79.039	1	0.001
Education	28.575	1	0.001
Socioeconomic status	48.680	1	0.001
Omnibus Test of Model Coefficients	114.085	8	0.001
Cox & Snell R Square	0.747	—	—
Nagelkerke R Square	1.000	—	—
Hosmer–Lemeshow test	0.001	1	1.000
−2 Log Likelihood	0.001	—	—

The Omnibus Test of Model Coefficients yielded a Chi-Square value of 114.085 with 8 degrees of freedom and p = 0.001, indicating that the model containing the eight predictors provided a statistically significant improvement over the intercept-only model. The Cox and Snell R Square was 0.747, whereas the Nagelkerke R Square reached 1.000, and the Hosmer–Lemeshow test produced a Chi-Square value of 0.001 with p = 1.000. At first glance, these statistics might appear to indicate exceptionally strong predictive performance; however, such an interpretation would be misleading because the regression output also demonstrated perfect separation. Statistical procedures and regression assumptions must therefore be evaluated together rather than interpreting individual goodness-of-fit indices in isolation (Notoatmodjo, 2020; Riyanto, 2018; Sugiyono, 2021).

Perfect separation occurred because several predictor categories corresponded completely, or almost completely, with one preeclampsia severity category. For example, every respondent with a risk interpregnancy interval experienced severe preeclampsia, while all respondents with a non-risk interval experienced mild preeclampsia; similarly, all women with previous preeclampsia, all women with a family medical history, and all women classified as being at risk of obesity were concentrated in the severe category. Under these circumstances, conventional maximum-likelihood logistic regression coefficients may become unstable or non-finite, producing extremely large or undefined odds ratios and standard errors. Consequently, the Exp(B) values from this model should not be interpreted as valid estimates of the magnitude of risk, and the variable with the largest Chi-Square statistic should be described as having the greatest statistical contribution rather than being identified definitively as the most dominant causal factor.

This statistical limitation is particularly important when interpreting the role of interpregnancy interval. Although its Chi-Square value of 83.000 was the largest among all variables, it would be inappropriate to conclude that pregnancy spacing independently causes or explains the greatest proportion of severe preeclampsia. The apparent strength of the relationship may partly reflect the exceptionally polarized distribution of respondents within this specific hospital-based sample. Similar caution applies to education and socioeconomic status, because the observed direction of association did not necessarily follow conventional expectations, demonstrating that statistical significance alone does not establish a biological mechanism or causal pathway. The findings should therefore be understood as evidence of associations requiring clinical contextualization and, ideally, confirmation in larger samples using analytic approaches capable of addressing separation.

The integrated pattern identified in this study remains clinically meaningful despite these statistical constraints. Maternal age, previous preeclampsia, family medical history, obesity, pregnancy spacing, knowledge and attitudes, education, and socioeconomic circumstances can all be evaluated during antenatal care and used to construct a broader maternal risk profile. Regular antenatal attendance may facilitate early detection of hypertension and reinforce maternal knowledge regarding warning signs and treatment adherence (Daeli et al., 2023), while appropriate management is essential to prevent progression toward eclampsia, HELLP syndrome, pulmonary edema,

neurological complications, and other severe outcomes (Bernolian et al., 2023; Katsi et al., 2024). Nutritional and preventive measures may also have a complementary role in selected pregnant populations, including attention to calcium and folate intake where clinically appropriate (Kaldygulova et al., 2023; Tiara Deka et al., 2022).

The implications of these results extend beyond individual clinical factors to the broader organization of maternal health services. Hypertensive disorders of pregnancy continue to represent an important maternal health concern in Indonesia and Central Java, making systematic screening, timely referral, and accessible antenatal services essential components of maternal mortality prevention (Dinas Kesehatan Provinsi Jawa Tengah, 2025; Kementerian Kesehatan Republik Indonesia, 2024). The World Health Organization (2025) similarly emphasizes that preventable maternal deaths remain closely linked to timely access to quality care before, during, and after childbirth. In the context of Dr. H. Soewondo General Hospital, the presence of 37 severe preeclampsia cases among 83 respondents indicates that hospital-level management should be accompanied by earlier risk identification in primary and antenatal care settings so that women with multiple risk characteristics can be referred before severe complications develop.

The multivariable analysis indicates that preeclampsia severity in this population was associated with a constellation of maternal, obstetric, metabolic, behavioral, educational, and socioeconomic factors rather than a single isolated predictor. Interpregnancy interval showed the greatest statistical contribution based on its Chi-Square value of 83.000, followed by knowledge and attitudes at 79.039 and maternal age at 75.242, while the complete model was statistically significant with an Omnibus Chi-Square of 114.085 and $p = 0.001$. Nevertheless, the occurrence of perfect separation, a Nagelkerke R Square of 1.000, and a −2 Log Likelihood of 0.001 indicates that the model estimates are not sufficiently stable to support definitive ranking of causal dominance or interpretation of Exp(B) values. These results therefore support an integrated antenatal strategy focused on comprehensive risk assessment, maternal education, regular clinical monitoring, and early referral, while future studies should employ larger and more heterogeneous samples and statistical methods that are robust to separation to obtain more reliable effect estimates.

CONCLUSION

This study demonstrates that maternal age, previous history of preeclampsia, family medical history, obesity, interpregnancy interval, knowledge and attitudes, educational level, and socioeconomic status were significantly associated with preeclampsia severity among pregnant women treated in the Mawar Ward of Dr. H. Soewondo General Hospital, Kendal, with all variables showing $p = 0.001$. Interpregnancy interval produced the largest Chi-Square value (83.000), followed by knowledge and attitudes (79.039) and maternal age (75.242), indicating that these variables made the greatest statistical contributions within the observed model. These findings reinforce the multifactorial nature of preeclampsia and emphasize the importance of integrating maternal, obstetric, metabolic, behavioral, educational, and socioeconomic characteristics into antenatal risk assessment.

The overall logistic regression model was statistically significant, with an Omnibus Chi-Square value of 114.085 and $p = 0.001$, while the Cox and Snell R Square and Nagelkerke R Square values were 0.747 and 1.000, respectively. However, the presence of perfect separation indicates that the regression coefficients and Exp(B) values cannot be reliably interpreted to identify a definitively dominant factor, despite the strong statistical contribution of interpregnancy interval. Therefore, the findings should be applied primarily to support comprehensive risk screening, maternal education, continuous antenatal monitoring, and timely referral of high-risk pregnant women. Future studies involving larger and more heterogeneous populations and statistical methods that can appropriately address separation are recommended to obtain more stable estimates of independent risk effects.

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