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Maternal preeclampsia and the gestational age profile of preterm births: A hospital-based cross-sectional study

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Abstract:
Preterm birth remains the leading cause of under-five mortality, and preeclampsia is one of its main obstetric drivers. This study examined the association between maternal preeclampsia and gestational age category among preterm infants at Gambiran Regional Public Hospital, Kediri City. An analytical cross-sectional study was conducted using medical records of all preterm live births over one calendar year (total sampling, n = 215). Gestational age was classified as extremely (<28 weeks), very (28 to <32 weeks), or moderate-to-late preterm (32 to <37 weeks). Data were analyzed using Pearson's chi-square test, Cramér's V, a linear-by-linear trend test, and odds ratios with 95% confidence intervals. Overall, 54.0% of preterm infants were born to mothers with preeclampsia, and 53.5% were moderate-to-late preterm. Gestational age category differed significantly by preeclampsia status (χ^2 = 6.42, df = 2, p = 0.040; Cramér's V = 0.17), with a shift towards later gestation (trend p = 0.015). Preeclampsia was associated with lower odds of extremely preterm birth (OR = 0.38; 95% CI: 0.16–0.89). Preeclampsia accounted for more than half of preterm births, mostly at moderate-to-late gestation, underscoring the need for early antenatal screening, timely prevention, and planned neonatal care.

Keywords:
gestational age; hypertensive disorders of pregnancy; Indonesia; preeclampsia; preterm birth

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INTRODUCTION

Preterm birth, defined as a live birth before 37 completed weeks of gestation, is a major global health problem. An estimated 13.4 million babies were born preterm in 2020, representing 9.9% of all live births, with little change in rates over the preceding decade (Ohuma et al., 2023). Complications of preterm birth are now the leading single cause of death among children under five years of age (Perin et al., 2022). Survivors face higher risks of respiratory distress, infection, intraventricular hemorrhage, and later neurodevelopmental problems, and the burden rises sharply as gestational age falls (Zivaljevic et al., 2024).

Gestational age is a key determinant of survival and clinical outcomes among preterm infants. Infants born at earlier gestational ages generally require more intensive respiratory support, thermal regulation, nutritional assistance, and monitoring for complications. Consequently, describing the

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distribution of preterm births across gestational age categories can help hospitals anticipate neonatal care requirements and allocate resources more effectively. When preterm birth occurs in the context of preeclampsia, this distribution may also reflect clinical decisions to deliver early to prevent maternal or fetal deterioration. Examining gestational age alongside maternal preeclampsia status may therefore provide useful information for both obstetric decision-making and neonatal service planning.

Indonesia is among the countries with the largest absolute numbers of preterm births, which places a heavy load on neonatal services and families (Chawanpaiboon et al., 2019; Rohsiswatmo et al., 2023). Local hospital records illustrate this burden. At Gambiran Regional Public Hospital in Kediri City, East Java, the proportion of preterm births rose from 16.1% in 2016 to 17.2% in 2017, exceeding the proportions recorded at other hospitals in the city during the same period. These figures suggest that referral hospitals in the region manage a concentrated share of high-risk pregnancies and preterm infants.

Preterm birth is not a single condition. About two-thirds of cases follow spontaneous preterm labor or preterm prelabour rupture of membranes, while about one-third are medically indicated, meaning that clinicians deliver the baby early because continuing the pregnancy threatens the mother or the fetus (Goldenberg et al., 2008). Spontaneous preterm labor is driven by several pathways, including intrauterine infection and inflammation, uterine overdistension, decidual hemorrhage, and placental vascular disease (Romero et al., 2014; Preston et al., 2024). Indicated preterm birth, in contrast, is dominated by maternal hypertensive disorders and fetal growth restriction. Distinguishing these routes matters because they require different prevention strategies and result in different gestational ages at birth.

Preeclampsia is a pregnancy-specific disorder defined by new-onset hypertension after 20 weeks of gestation accompanied by proteinuria or other signs of maternal organ or uteroplacental dysfunction (American College of Obstetricians and Gynecologists [ACOG], 2020; Magee et al., 2022). It complicates around 4.6% of pregnancies worldwide (Abalos et al., 2013), and hypertensive disorders of pregnancy remain one of the leading causes of maternal death in Indonesia (Syairaji et al., 2024). The disorder begins with abnormal placentation and reduced uteroplacental perfusion. The stressed placenta releases anti-angiogenic factors, such as soluble fms-like tyrosine kinase-1 (sFlt-1), which damage the maternal endothelium and lead to hypertension and multi-organ injury (Chappell et al., 2021; Rana et al., 2019). Oxidative stress and placental mitochondrial dysfunction further amplify this process (Jahan et al., 2023).

Because delivery of the placenta is the only definitive treatment, preeclampsia is closely tied to preterm birth. Clinical guidelines recommend delivery at 34 weeks for preeclampsia with severe features and at 37 weeks for disease without severe features, or earlier if the condition of the mother or fetus deteriorates (ACOG, 2020). Trials of planned early delivery versus expectant management show that the timing decision balances maternal safety against the neonatal costs of prematurity (Koopmans et al., 2009; Broekhuijsen et al., 2015; Chappell et al., 2019). Hospital-based studies from different regions consistently report more preterm births, low birth weight, and neonatal intensive care admissions among women with preeclampsia (Davies et al., 2016; Kumsa & Mergiyaw, 2024; Socol et al., 2024). The effects also extend beyond the neonatal period, since

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children exposed to preeclampsia in utero show higher risks of neurodevelopmental, metabolic, and cardiovascular problems later in life (Koulouraki et al., 2023).

Much of this evidence comes from high-income settings or from studies that compare women with and without preeclampsia across all births. Less is known about how preeclampsia shapes the gestational age profile of preterm infants admitted to regional referral hospitals in Indonesia. This information is practical. The gestational age mix of preterm infants determines the level of neonatal care, staffing, and equipment a hospital needs, and it shows where antenatal prevention, such as low-dose aspirin and calcium supplementation for women at high risk, could have the greatest effect (Rolnik et al., 2017; Woo Kinshella et al., 2022).

However, the proportion of preterm infants in each gestational age category and its relationship with maternal preeclampsia may vary across hospitals because of differences in referral patterns, maternal risk profiles, and clinical management. Evidence from a regional referral hospital in Indonesia can help characterize this local pattern and identify whether preeclampsia is associated with earlier gestational age at birth among preterm infants. Such findings may support the interpretation of local maternal and neonatal service needs, although a hospital-based observational study cannot establish causation or represent the distribution of preterm births in the wider community. Therefore, this study aimed to describe the distribution of preterm births by gestational age category and maternal preeclampsia status, and to examine the association between maternal preeclampsia and gestational age category among preterm infants born at the Gambiran Regional Public Hospital in Kediri City.

METHODS

This study employed an analytical observational design with a cross-sectional approach using retrospective medical record review. It was conducted at Gambiran Regional Public Hospital, a government referral hospital in Kediri City, East Java, Indonesia. The hospital provides obstetric and neonatal services and receives referrals for complicated pregnancies from primary healthcare facilities and smaller hospitals in the surrounding area. Data were collected in August 2025 and covered eligible preterm live births recorded between January and December 2025. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for cross-sectional studies (von Elm et al., 2007).

The study population comprised all live-born infants delivered before 37 completed weeks of gestation at Gambiran Regional Public Hospital between January and December 2025. Total sampling was used, meaning that all medical records that met the eligibility criteria during the study period were considered for inclusion. This approach was intended to capture the complete set of eligible preterm births documented at the hospital during the specified 12-month period.

Records were eligible if the infant was born alive before 37 completed weeks of gestation, regardless of delivery mode, and the corresponding maternal medical record documented both gestational age at birth and maternal preeclampsia status. Records were excluded if they were illegible, incomplete, or lacked either of the two primary study variables. After applying these criteria, 215 preterm infants met the eligibility requirements and were included in the final analysis.

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The unit of analysis was the preterm infant and the corresponding maternal record. The final dataset was checked to ensure that each eligible observation was included only once. If multiple births from the same pregnancy were included, the potential dependence between observations would need to be considered when interpreting the statistical results.

The dependent variable was gestational age category at birth. Gestational age was obtained from the medical record and was documented as being calculated from the first day of the last menstrual period. Following the World Health Organization classification, gestational age was categorized into three mutually exclusive groups: extremely preterm (<28 completed weeks), very preterm (28 to <32 completed weeks), and moderate-to-late preterm (32 to <37 completed weeks). These categories were used to describe the distribution of preterm births and examine whether gestational age at birth differed according to maternal preeclampsia status.

The independent variable was maternal preeclampsia status, classified as present or absent based on the attending obstetrician's diagnosis. Preeclampsia was defined as new-onset hypertension after 20 weeks of gestation, indicated by systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg, accompanied by proteinuria or other evidence of maternal organ dysfunction, in accordance with international diagnostic criteria (ACOG, 2020; Magee et al., 2022). The documented clinical diagnosis was used for classification, and the researchers did not independently re-diagnose preeclampsia from the available records.

Maternal parity was extracted as an additional descriptive variable and classified as primiparous or multiparous. Primiparous referred to women giving birth for the first time, whereas multiparous referred to women who had given birth previously. Parity was included to describe the maternal characteristics of the study population but was not included as an adjustment variable in the primary association analysis.

Data were extracted retrospectively from hospital medical records using a structured checklist developed in accordance with the study objectives and operational definitions. The checklist covered gestational age at birth, maternal preeclampsia status, and parity. The extracted data were reviewed for completeness, consistency, and correct classification before analysis. Records missing either gestational age or maternal preeclampsia status were excluded because these variables were essential to the primary analysis.

Each eligible record was assigned a unique study code. Names, medical record numbers, and other direct personal identifiers were not entered into the analytical dataset. The extracted information was organized into a structured dataset, and variable coding was checked for errors and inconsistencies before statistical analysis. Because the study relied on existing clinical documentation, the completeness and accuracy of the original medical records were important considerations when interpreting the findings.

Statistical analysis was conducted in several stages. First, descriptive statistics were used to summarize the study population. Categorical variables, including gestational age category, maternal preeclampsia status, and parity, were presented as frequencies and percentages. The corresponding 95% confidence intervals (CIs) for proportions were calculated using the Wilson method.

Second, the association between maternal preeclampsia status and gestational age category was assessed using Pearson's chi-square test of independence. The analysis used a 3 × 2 contingency table consisting of three gestational age categories and two maternal preeclampsia

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categories. All expected cell counts exceeded five, satisfying the expected-frequency assumption for the chi-square test (Kim, 2017). Statistical significance was determined using a two-sided p-value of <0.05.

Third, Cramér's V was calculated to assess the magnitude of the association between maternal preeclampsia status and gestational age category. This effect-size measure was reported alongside the chi-square statistic to provide information about the strength of the association beyond statistical significance. Because gestational age category is ordinal, a linear-by-linear association test was also performed to examine whether the distribution showed a statistically significant trend across the ordered categories.

Finally, category-specific crude odds ratios (ORs) and their 95% CIs were calculated to further characterize the observed association. For each gestational age category, infants in that category were compared with infants in the other two categories combined. The odds of belonging to the specified category among infants born to mothers with preeclampsia were then compared with the corresponding odds among infants born to mothers without preeclampsia. These estimates were unadjusted for potential confounding variables and were interpreted as category-specific associations among preterm births, rather than estimates of the risk of preterm birth in the general obstetric population. All analyses were performed using statistical software, and the software name and version should be specified in the final manuscript.

Confidentiality was maintained throughout data extraction, data management, and analysis. Each record was identified using a study code, and direct personal identifiers were excluded from the analytical dataset. The manuscript should report the name of the research ethics committee, approval number and date, and whether informed consent was waived, where applicable. These details should be added in accordance with the actual ethics approval and institutional requirements.

RESULTS

Among the 215 preterm infants included in the analysis, 115 (53.5%) were moderate-to-late preterm, 73 (34.0%) were very preterm, and 27 (12.6%) were extremely preterm. Maternal preeclampsia was documented in 116 cases (54.0%; 95% CI: 47.3–60.5), while 129 mothers (60.0%) were primiparous. The characteristics of the study population are presented in Table 1.

Table 1. Characteristics of preterm infants and their mothers (n = 215)

Characteristic	n	%	95% CI
Gestational age at birth			
Extremely preterm (<28 weeks)	27	12.6	8.8–17.7
Very preterm (28 to <32 weeks)	73	34.0	28.0–40.5
Moderate-to-late preterm (32 to <37 weeks)	115	53.5	46.8–60.0
Maternal preeclampsia			
Preeclampsia	116	54.0	47.3–60.5
No preeclampsia	99	46.0	39.5–52.7
Parity			
Primiparous	129	60.0	53.3–66.3
Multiparous	86	40.0	33.7–46.7

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The distribution of gestational age categories differed by maternal preeclampsia status (Table 2). Among infants of mothers with preeclampsia, 59.5% were moderate-to-late preterm and 7.8% were extremely preterm, compared with 46.5% and 18.2%, respectively, among infants of mothers without preeclampsia. The association was statistically significant ($\chi^2 = 6.42$, df = 2, p = 0.040) and small in magnitude (Cramér's V = 0.17). The linear-by-linear test confirmed a significant trend ($\chi^2 = 5.93$, df = 1, p = 0.015), indicating that preterm infants of mothers with preeclampsia were concentrated at later gestational ages.

Table 2. Gestational age categories of preterm infants according to maternal preeclampsia status

Gestational age category	Preeclampsia (n = 116) n (%)	No preeclampsia (n = 99) n (%)	Total (N = 215) n (%)	χ^2	p-value	Cramér's V
Extremely preterm (<28 weeks)	9 (7.8)	18 (18.2)	27 (12.6)	6.42	0.040	0.17
Very preterm (28 to <32 weeks)	38 (32.8)	35 (35.4)	73 (34.0)			
Moderate-to-late preterm (32 to <37 weeks)	69 (59.5)	46 (46.5)	115 (53.5)			

Table 3. Odds of each gestational age category among preterm infants of mothers with preeclampsia compared with those without preeclampsia

Gestational age category (vs. other categories)	Crude OR	95% CI	p-value
Extremely preterm (<28 weeks)	0.38	0.16–0.89	0.022
Very preterm (28 to <32 weeks)	0.89	0.51–1.57	0.689
Moderate-to-late preterm (32 to <37 weeks)	1.69	0.98–2.91	0.056

Pairwise comparisons showed that the overall association was driven mainly by the extremely preterm group (Table 3). Maternal preeclampsia was associated with 62% lower odds of extremely preterm birth (OR = 0.38; 95% CI: 0.16–0.89; p = 0.022). There was no difference for the very preterm category (OR = 0.89; 95% CI: 0.51–1.57; p = 0.689), and the higher odds of moderate-to-late preterm birth did not reach statistical significance (OR = 1.69; 95% CI: 0.98–2.91; p = 0.056). Viewed by row, preeclampsia was present in 33.3% of extremely preterm infants, 52.1% of very preterm infants, and 60.0% of moderate-to-late preterm infants.

Taken together, the findings show a gradual increase in the proportion of maternal preeclampsia across the gestational age categories, from 33.3% among extremely preterm infants to 60.0% among moderate-to-late preterm infants. The overall association was statistically significant, but the effect size was small. The category-specific analysis indicated that the clearest difference was observed among extremely preterm infants, whereas the association for moderate-to-late preterm infants did not reach statistical significance. These results describe differences in the gestational age distribution according to maternal preeclampsia status among preterm births in this hospital.

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DISCUSSION

This study found that more than half of the preterm infants born at a regional referral hospital in East Java had mothers with preeclampsia, and that most preterm infants were moderate-to-late preterm. Maternal preeclampsia was significantly associated with gestational age category. Preterm infants of mothers with preeclampsia were concentrated at 32 to 36 weeks, whereas extremely preterm births were more common among mothers without preeclampsia. The effect size was small, which is expected when both groups already share the common outcome of preterm birth, but the direction of the trend was consistent across all three categories.

The high proportion of preeclampsia in this sample is the first notable finding. Preeclampsia complicates around 4.6% of pregnancies worldwide (Abalos et al., 2013), yet it was documented in 54.0% of the mothers of preterm infants in this hospital. Although the absence of a term comparison group means that the risk of preterm birth attributable to preeclampsia cannot be estimated, this marked over-representation agrees with population and hospital studies showing a strong link between preeclampsia and preterm delivery (Davies et al., 2016; Kumsa & Mergiyaw, 2024; Socol et al., 2024). It also reflects the role of the hospital as a referral center that receives women with hypertensive complications. In Indonesia, hypertensive disorders of pregnancy remain one of the main causes of maternal death (Syairaji et al., 2024), so the same women who contribute to preterm birth figures also represent an important share of maternal risk.

The second finding, the shift of preeclampsia-related preterm births towards later gestation, is best explained by the way preeclampsia is managed. Preterm births fall into two broad groups: spontaneous births following preterm labor or rupture of membranes, and medically indicated births (Goldenberg et al., 2008). Preeclampsia is a leading reason for indicated preterm birth. Current guidelines advise expectant management with close monitoring until 34 weeks for preeclampsia with severe features and until 37 weeks for disease without severe features, with earlier delivery only if the mother or fetus deteriorates (ACOG, 2020; Magee et al., 2022). Randomized trials support this approach. The HYPITAT trial showed that induction of labor from 36 weeks improved maternal outcomes in mild hypertensive disease (Koopmans et al., 2009), HYPITAT-II showed that immediate delivery between 34 and 37 weeks reduced a small maternal risk at the cost of more neonatal respiratory distress (Broekhuijsen et al., 2015), and the PHOENIX trial found that planned delivery for late preterm preeclampsia reduced maternal morbidity without increasing serious neonatal morbidity (Chappell et al., 2019). In practice, these recommendations move many preeclampsia-related births into the moderate-to-late preterm window, which is exactly the pattern observed in this study.

Another important consideration is the need to interpret gestational age distribution alongside the clinical characteristics of each pregnancy. Although preeclampsia was associated with gestational age category in this study, the observed pattern may also reflect differences in disease severity, timing of diagnosis, fetal condition, and decisions regarding delivery. Without information on these factors, it is not possible to determine whether the higher concentration of moderate-to-late preterm births reflects planned early delivery, differences in disease progression, or other obstetric complications. Future studies should therefore record the indication for delivery, onset and severity of preeclampsia, fetal growth status, and major maternal comorbidities. These data

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would provide a clearer understanding of the clinical pathways linking preeclampsia with gestational age at birth and help distinguish potentially preventable preterm births from those required to protect maternal or fetal health.

Extremely preterm births, in contrast, are more often the result of spontaneous processes such as intrauterine infection and inflammation, cervical insufficiency, and decidual bleeding (Romero et al., 2014). These pathways operate largely independently of maternal blood pressure, which may explain why mothers without preeclampsia contributed a larger share of births before 28 weeks. Placental insufficiency can also trigger spontaneous preterm labor (Preston et al., 2024), so the boundary between the two routes is not absolute. The nine extremely preterm infants born to mothers with preeclampsia probably represent early-onset, severe disease, in which deep placental malperfusion and high levels of anti-angiogenic factors such as sFlt-1 lead to rapid maternal deterioration (Rana et al., 2019; Chappell et al., 2021). Oxidative stress and placental mitochondrial dysfunction add to this vascular injury (Jahan et al., 2023). Records in this study did not distinguish between early- and late-onset disease, and future work should capture this information.

These findings matter for neonatal care. Moderate-to-late preterm infants are sometimes regarded as low risk, yet they still experience more respiratory, feeding, thermoregulation, and infection problems than term infants and account for a large share of neonatal admissions because of their numbers (Zivaljevic et al., 2024). In addition, infants exposed to preeclampsia in utero carry their own risks related to placental insufficiency, including growth restriction and later neurodevelopmental and cardiovascular problems (Koulouraki et al., 2023). Since preterm birth complications are the leading cause of death in children under five (Perin et al., 2022), a hospital in which preeclampsia accounts for most moderate-to-late preterm births should plan neonatal resources around this group. Practical measures include anticipating deliveries of mothers with preeclampsia, coordinating timing between obstetric and neonatal teams, and preparing staff for the care of late preterm infants. Long-term follow-up programs, such as the cohort being developed for Indonesian preterm infants (Rohsiswatmo et al., 2023), could also include maternal preeclampsia status as a key variable.

Prevention and early detection offer the clearest route to reducing this burden. Low-dose aspirin initiated before 16 weeks of gestation in women at high risk substantially reduces the risk of preterm preeclampsia (Rolnik et al., 2017; Wang et al., 2022). Calcium supplementation reduces the risk of preeclampsia, particularly in populations with low dietary calcium intake (Gomes et al., 2022; Woo Kinshella et al., 2022), a pattern relevant to many Indonesian populations. Nulliparity is an established risk factor (ACOG, 2020), and 60.0% of mothers in this sample were primiparous; therefore, first pregnancies warrant particular attention in antenatal risk assessment. In referral settings, the sFlt-1/PlGF ratio can help clinicians rule out preeclampsia in the short term and target surveillance to women who need it most (Zeisler et al., 2016). At the primary care level, regular blood pressure and urine protein checks by midwives and nurses remain the foundation of early detection. Antenatal assessment should also look beyond blood pressure. Nurses working in agricultural communities have been encouraged to include environmental exposure histories in prenatal assessments because such exposures are linked to adverse maternal and fetal outcomes, including low birth weight (Kurniyawan et al., 2026). A comprehensive, nurse- and midwife-led

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antenatal assessment that combines clinical, obstetric, and environmental risk factors may help identify women who need referral before complications become severe.

This study has several strengths. It included every eligible preterm birth over a full calendar year at a busy referral hospital, used an internationally recognized gestational age classification, and reported effect sizes and confidence intervals rather than relying on p-values alone. Several limitations should also be considered. First, only preterm infants were included, so the study describes how preeclampsia shapes the gestational age profile of preterm births but cannot estimate the risk of preterm birth associated with preeclampsia. Second, data came from routine medical records, which may contain misclassification of gestational age or diagnosis and did not record preeclampsia severity, time of onset, or whether the birth was spontaneous or indicated. Third, the analysis was bivariate, and confounding factors such as maternal age, parity, multiple pregnancy, and other medical conditions could not be adjusted for. Fourth, the cross-sectional design does not establish temporal or causal relationships, and findings from a single referral hospital may not be generalizable to community settings. Future studies should use case-control or cohort designs that include term births, distinguish spontaneous from indicated preterm birth, record disease onset and severity, and apply multivariable analysis.

The findings highlight the need for coordinated maternal and neonatal care. Primary care providers should identify hypertensive disorders early, monitor pregnancies, and refer high-risk women promptly. Referral hospitals should strengthen coordination between obstetric and neonatal teams, supported by standardized referrals and shared clinical records. Although referral pathways were not evaluated, these findings provide a basis for local quality-improvement initiatives to improve outcomes for mothers with preeclampsia and their preterm infants.

CONCLUSION

More than half of preterm infants born at Gambiran Regional Public Hospital, Kediri City, had mothers with preeclampsia, and most preterm infants were born at moderate-to-late gestation. Maternal preeclampsia was significantly associated with gestational age category, with preeclampsia-related preterm births concentrated at 32 to 36 weeks and fewer extremely preterm births. This pattern is consistent with medically indicated delivery as a key pathway linking preeclampsia to preterm birth. Future multicenter studies with term comparison groups and multivariable analysis are needed to quantify the contribution of preeclampsia to preterm birth in Indonesia.

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CONFLICT OF INTEREST

The author declares no financial or personal conflicts of interest related to this study.

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