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The risk and obstetric outcomes of preeclampsia in pregnancies with non-ideal maternal age: a systematic review

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ABSTRACT

Preeclampsia remains a leading cause of maternal and neonatal morbidity, with increased risk observed at both extremes of maternal age adolescents (<20 years) and women of advanced maternal age (>35 years). However, the comparative obstetric impacts of preeclampsia across these age groups remain underexplored in a structured synthesis. This study aims to provide an up-to-date, evidence-based understanding to support maternal health policy planning, clinical obstetrics, and reproductive education tailored to high-risk populations. This systematic review was conducted following PRISMA guidelines. Electronic databases including PubMed, Scopus, and Google Scholar were searched for peer-reviewed studies published between 2015 and 2025. Studies were eligible if they reported preeclampsia prevalence and obstetric outcomes among pregnant individuals aged <20 or >35 years. Seven observational and cohort studies met the inclusion criteria. Adolescent pregnancies complicated by preeclampsia showed high cesarean section rates (82.9% in those aged ≤16 and 89.3% in ages 17–19), and increased risk of anemia and pregnancy complications despite comparable neonatal outcomes across age subgroups. In contrast, advanced maternal age was associated with a higher prevalence of severe preeclampsia (68.9%), eclampsia (12.3%), HELLP syndrome (8.7%), and emergency cesarean delivery (71.3%). Neonatal complications included low birth weight (34.4%) and lower five-minute Apgar scores. Use of assisted reproductive technologies in women ≥40 further amplified the risk of early-onset preeclampsia and prematurity. Pregnancies at non-ideal maternal ages carry distinct pathophysiological risks and result in increased obstetric complexity and need for medical intervention. Age-specific clinical approaches such as early screening, targeted antenatal education, and enhanced maternal-fetal surveillance are essential. These findings support maternal health policies that incorporate maternal age as a key determinant for individualized risk assessment and care planning.

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INTRODUCTION

Preeclampsia is a serious pregnancy complication characterized by hypertension and organ dysfunction, representing one of the leading causes of maternal and neonatal morbidity and mortality worldwide.(1) The risk of developing preeclampsia is elevated in pregnancies involving non-ideal maternal ages, both in younger mothers (<20 years) and advanced maternal age (>35 years), which is associated with physiological imbalances and suboptimal immune responses to pregnancy.(2) Given the global trend of delayed childbearing alongside an increasing number of adolescent pregnancies in several developing countries, understanding the relationship between non-ideal maternal age and obstetric outcomes due to preeclampsia becomes critical for effective prevention and management efforts.(3) However, despite increasing evidence linking maternal age to obstetric complications, there remains a critical gap in synthesizing how preeclampsia specifically affects pregnancy outcomes among women with non-ideal maternal age.

Numerous systematic reviews and meta-analyses have demonstrated that pregnancies in both adolescent and advanced maternal age groups significantly increase the risk of preeclampsia and other obstetric complications such as preterm birth, low birth weight, and perinatal mortality.(4)(5) For example, Hedermann et al. (2025) underscored that women over 35 years old have a higher risk of preeclampsia even after adjusting for other comorbid factors.(6) Similarly, Chen et al. (2025), in their analysis of risk factors for placental abruption, found that maternal age ≥35 years is a strong predictor that is also associated with preeclampsia.(7)

Although numerous systematic reviews on preeclampsia exist, there is currently no comprehensive review specifically examining the impact of preeclampsia on obstetric outcomes with an exclusive focus on non-ideal maternal age groups. Previous studies have often controlled for maternal age rather than exploring it as the central exposure variable, thereby underestimating its direct impact on the severity and outcomes of preeclampsia. Most literature incorporates maternal age as a control variable or discusses only older age groups without adequately addressing younger mothers. Therefore, there is a need for an evidence synthesis that focuses primarily on at-risk populations defined by maternal age as the primary variable, to close this knowledge gap.(8,9) A systematic review is the most appropriate approach to comprehensively synthesize findings across diverse populations and study designs, ensuring evidence-based recommendations for high-risk groups.

This review aims to systematically examine the risk patterns and obstetric impacts of preeclampsia in pregnancies with non-ideal maternal age (<20 and >35 years). This study aims to provide an up-to-date, evidence-based understanding to support maternal health policy planning, clinical obstetrics, and reproductive education tailored to high-risk populations. The scope of the review includes observational studies, cohort studies, and clinical trials published between 2015 and 2025 that investigate the relationship between non-ideal maternal age and obstetric outcomes related to preeclampsia across various regions worldwide.

METHOD

This study employed a systematic literature review (SLR) approach to synthesize current evidence regarding the risks and obstetric outcomes of preeclampsia in pregnancies among women of non-ideal maternal age (<20 years and >35 years). The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Although the protocol was developed a priori, it was not registered in PROSPERO or other review databases. Studies were eligible for inclusion if they met the following criteria: population (Pregnant women under 20 years old or over 35 years old), exposure (Diagnosis of preeclampsia, as defined by each study, outcomes (Any reported obstetric outcomes, including but not limited to preterm birth, low birth weight, cesarean section, stillbirth, or maternal complications),study design (Observational studies

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(cross-sectional, case-control, cohort) or clinical trials, timeframe (Published between January 2015 and April 2025), language (English). Studies were excluded if they were review articles, case reports, commentaries, or editorials; did not report maternal age as a primary variable of interest; did not include preeclampsia as an exposure or focus; lacked relevant obstetric outcome data. A comprehensive literature search was conducted across three major electronic databases: PubMed, Scopus, and Google Scholar. The search was conducted in April 2025 using a combination of controlled vocabulary (MeSH terms) and free-text keywords. Search terms included: *("preeclampsia" OR "hypertensive disorders in pregnancy") AND ("maternal age" OR "adolescent pregnancy" OR "advanced maternal age") AND ("obstetric outcomes" OR "pregnancy outcomes").* Search strategies were adapted to each database, and Boolean operators were used to refine results. Reference lists of relevant studies were manually screened for additional eligible publications. The initial search identified 999 articles.

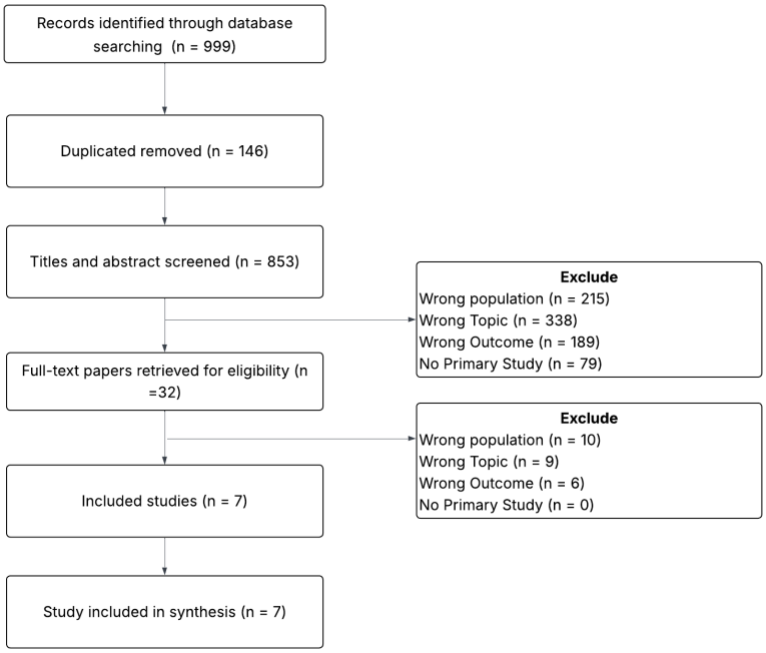

Figure 1. Flowchart of the Review Process

After removing 146 duplicates, 853 articles were screened based on titles and abstracts. 821 articles were excluded for not meeting inclusion criteria, leaving 32 articles for full-text review. Of these, 25 were excluded due to inadequate reporting of maternal age categories, absence of preeclampsia as a primary variable, or lack of obstetric outcomes. Finally, 7 studies were included for qualitative synthesis. The entire selection process followed the PRISMA flowchart, and discrepancies between reviewers were resolved by consensus. Data extraction was independently conducted by two reviewers using a standardized data extraction form. The following variables were collected: first author, publication year, country of study; study design and sample size; maternal age categories (<20, 20–34, >35 years); definition and diagnostic criteria of preeclampsia; reported obstetric outcomes; key findings related to the association between maternal age and preeclampsia outcomes. Disagreements in data extraction were resolved through discussion. The methodological quality of included studies was appraised using the Joanna Briggs Institute (JBI) Critical Appraisal Checklists for observational studies (cohort and case-control). Each study was independently assessed by two reviewers. Studies were not

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excluded based on quality but were considered in the interpretation of findings. A narrative synthesis approach was employed due to heterogeneity in study design, population characteristics, and outcome measurements. Findings were grouped thematically according to maternal age category (<20 years and >35 years) and obstetric outcomes. Patterns of association between maternal age, preeclampsia, and pregnancy outcomes were descriptively summarized.

RESULTS

A total of seven studies met the inclusion criteria after the screening and eligibility process. All studies examined the association between maternal age and preeclampsia or related obstetric outcomes. The quality of each included study was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for analytical cross-sectional and cohort studies.

As presented in Table 1, most studies demonstrated moderate to high methodological quality. Six out of seven studies clearly defined inclusion criteria (Q1), provided detailed descriptions of study subjects and settings (Q2), and applied valid and reliable measurements for both exposures and outcomes (Q3, Q7). However, several studies (e.g., Husna et al., 2019) did not adequately identify or address potential confounding factors (Q5–Q6). All studies performed appropriate statistical analyses (Q8), and four studies (Buciu et al., 2025; Gurza et al., 2025; Li et al., 2025; Lazzari et al., 2025) achieved full scores across all appraisal domains, reflecting strong methodological rigor and low risk of bias.

Table 1. Critical Appraisal of Included Studies

Author, Year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Pingel et al. 2017	Y	Y	Y	Y	U	N	Y	Y
Husna et al., 2019	Y	Y	U	N	N	N	Y	Y
Buciu et al., 2025	Y	Y	Y	Y	Y	Y	Y	Y
Gurza et al., 2025	Y	Y	Y	Y	Y	Y	Y	Y
Li et al., 2025	Y	Y	Y	Y	Y	Y	Y	Y
Chonnak et al., 2025	Y	Y	Y	Y	Y	Y	Y	Y
Lazzari et al., 2025	Y	Y	Y	Y	Y	Y	Y	Y

Note. JBI Critical Appraisal Checklist Criteria:
Q1 Were the criteria for inclusion in the sample clearly defined?
Q2 Were the study subjects and the setting described in detail?
Q3 Was the exposure measured validly and reliably?
Q4 Were objective, standard criteria used for measurement of the condition?
Q5 Were confounding factors identified?
Q6 Were strategies to deal with confounding factors stated?
Q7 Were the outcomes measured validly and reliably?
Q8 Was appropriate statistical analysis used?

The characteristics of the seven included studies are summarized in Table 2**.** The studies were conducted across diverse geographical contexts; Ecuador, Indonesia, Romania, Mexico, China, Thailand, and Italy representing both low- and middle-income as well as high-income settings. Study designs were predominantly retrospective cohort (n=5), with one comparative retrospective and one prospective cohort study. Sample sizes ranged widely, from 40 participants (Husna et al., 2019) to over 67,000 (Chonnak et al., 2025), with maternal age definitions varying by context. Adolescent pregnancy was generally defined as ≤19 years, while advanced maternal age (AMA) was defined as ≥35 years, and extremely advanced maternal age (EAMA) as ≥45 years. Across studies, the primary focus was to assess the relationship between maternal age and preeclampsia incidence, and its subsequent impact on obstetric and neonatal outcomes such as cesarean delivery, preterm

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birth, low birth weight (LBW), neonatal intensive care unit (NICU) admission, and perinatal death.

Table 2. Characteristics of Included Studies

Author, Year	Country	Study Design	Sampel Size	Age Definition	Main Focus
Pingel et al., 2017	Ecuador	Comparative retrospective	213	Adolescents ≤16 years (n=82) vs 17–19 years (n=131)	Compared maternal and neonatal outcomes in adolescent pregnancies complicated by severe preeclampsia according to age group, focusing on mode of delivery, neonatal morbidity, and NICU admissions.
Husna et al., 2019	Indonesia	Retrospective cross-sectional observational	40	Adolescents ≤19 years vs women 20–35 years	Examined the association between adolescent pregnancy and pregnancy complications (including anemia, nutritional deficiencies, preeclampsia/eclampsia) and delivery complications.
Buciu et al., 2025	Romania	Retrospective cohort	700 (350 with preeclampsia)	Maternal age >18 years; subgroup analysis included age <35 vs ≥35 years	Developed and validated a second-trimester clinical risk score to predict preeclampsia using accessible clinical variables in low-resource settings; examined maternal and neonatal outcomes by risk stratification.
Gurza et al., 2025	Mexico	Prospective cohort	333	Maternal age >18 years (range: 18–40 years); age adjusted in analysis but no specific subgroup comparison	Assessed association between first-trimester triglyceride–glucose (TyG) index (>8.6) and risk of adverse perinatal outcomes, specifically gestational diabetes mellitus (GDM) and preeclampsia.
Li et al., 2025	China	Retrospective hospital-based cohort	20,882	Advanced maternal age (AMA) defined as ≥35 years; subgroup analysis for 35–40 years and ≥40 years	Evaluated the impact of IVF-ET on obstetric and perinatal outcomes in advanced maternal age women compared with spontaneous conceptions, using IPTW-adjusted regression and mediation analysis.
Chonnak et al., 2025	Thailand	Retrospective cohort	67,301; 121 women ≥45 years included in analysis	Extremely Advanced Maternal Age (≥45 years); compared to 20–34 years (control)	Investigated obstetric and perinatal outcomes among women near the end of reproductive age (≥45 years), focusing on preeclampsia, preterm birth, low birth weight, fetal growth restriction, and perinatal death.

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Author, Year	Country	Study Design	Sampel Size	Age Definition	Main Focus
Lazzari et al., 2025	Italy	Retrospective cohort	25,022	≤20 years (adolescent), ≥35 years (advanced age), ≥40 years (very advanced age)	Evaluated the continuous relationship between maternal age and the risk of hypertensive disorders of pregnancy (including preeclampsia), using penalized spline regression; also analyzed the modifying role of BMI and infertility treatments.

The synthesis of findings across the included studies is presented in **Table 3**. The results are organized according to maternal age categories **adolescent pregnancies (<20 years)** and **advanced maternal age pregnancies (>35 years)** to highlight the bidirectional risk pattern associated with both extremes of reproductive age.

Table 3. Summary of Key Findings

Author (Year)	Age Groups Compared	Incidence of Preeclampsia	Key Obstetric Outcomes Reported	Key Statistical Findings (OR, RR, p-value, CI)
Parra-Pingel et al. (2017)	≤16 years vs 17–19 years	All cases involved severe preeclampsia (100%)	Cesarean delivery, preterm birth, low birth weight (LBW), NICU admission, neonatal death	No significant differences between age groups ($p > 0.05$); cesarean section ≥80%; poor neonatal outcomes in both age groups.
Husna et al. (2019)	≤19 years vs 20–35 years	15% among adolescents vs 8% among adults	Anemia, preeclampsia/eclampsia, prolonged labor, cesarean section	Significant association between adolescent pregnancy and pregnancy complications ($p < 0.05$); no specific OR for preeclampsia reported.
Buciu et al. (2025)	<35 years vs ≥35 years	Higher in ≥35-year group	Cesarean delivery, NICU admission, neonatal asphyxia	Maternal age ≥35 years identified as a significant factor in preeclampsia risk score; specific OR not reported; age included as a predictive variable.
Gurza et al. (2025)	Continuous age analysis (18–40 years)	Not analyzed by age subgroup	Preeclampsia, gestational diabetes mellitus (GDM), preterm birth, NICU admission	Elevated TyG index (>8.6) significantly associated with preeclampsia risk (OR 4.32, 95% CI: 1.87–10.02, $p < 0.001$); age adjusted in model but not isolated.
Li et al. (2025)	35–40 years, ≥40 years (IVF vs spontaneous)	8.5% in IVF vs 5.3% in spontaneous conception	Cesarean delivery, preterm birth, LBW, NICU admission	IVF associated with increased preeclampsia risk (OR 1.49, 95% CI: 1.20–1.89, $p < 0.001$); 25.4% of preterm births mediated by preeclampsia.

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Author (Year)	Age Groups Compared	Incidence of Preeclampsia	Key Obstetric Outcomes Reported	Key Statistical Findings (OR, RR, p-value, CI)
Chonnak et al. (2025)	≥45 years vs 20–34 years	13.2% in ≥45 years vs 5.7% in controls	Preterm birth, LBW, fetal growth restriction, perinatal death	Significantly higher risk of preeclampsia in ≥45 years (OR 2.70, 95% CI: 1.90–3.78, p < 0.001); adverse neonatal outcomes also significantly higher (p < 0.001).
Lazzari et al. (2025)	≤20, 21–34, ≥35, ≥40 years	Progressively increased with maternal age; highest in ≥40 years	Cesarean section, severity of preeclampsia, maternal morbidity	Risk of hypertensive disorders increased progressively with age (p < 0.001); no specific cut-off; trend confirmed via spline regression; OR not reported.

A total of seven studies met the inclusion criteria and were included in this review. The findings are organized thematically based on maternal age categories: (1) adolescent pregnancies (<20 years) and (2) advanced maternal age pregnancies (>35 years).

Adolescent Pregnancies (<20 years)

Three studies investigated the obstetric outcomes of preeclampsia in adolescent pregnancies. In the study by Pingel et al., a total of 213 pregnant adolescent women with severe preeclampsia were analyzed, consisting of 82 women aged ≤16 years and 131 women aged 17–19 years. The results showed a very high cesarean section rate in both groups (82.9% vs. 89.3%), with no significant differences observed in maternal mortality, severe complications, neonatal death (0 vs. 4; p = 0.30), or neonatal outcomes such as low Apgar scores, prematurity, low birth weight, and small for gestational age.(10) A similar study by Husna et al., involving 40 pregnant women, compared adolescent mothers ≤19 years with women aged 20–35. Preeclampsia was found in only one case (5%) in the 20–35 years group and was absent in the adolescent group, with a non-significant difference (p = 0.300). However, overall pregnancy complications were significantly higher in the teenage group (p = 0.01; OR = 6), as was the incidence of anemia (p = 0.013; OR = 7.364).(11) Lazzari et al., analyzing 25,165 nulliparous pregnancies, reported that the prevalence of preeclampsia among adolescents aged ≤20 years was 1.7%, the lowest among all age categories.(12)

Advanced Maternal Age Pregnancies (>35 years)

Four studies examined outcomes in women of advanced maternal age and consistently reported elevated risks associated with preeclampsia. Buciu et al. developed a preeclampsia prediction model using 700 patients, comprising 350 preeclampsia cases and 350 controls. The model yielded an AUC of 0.91 and identified age >35, hypertension, and diabetes as significant risk factors. High-risk patients in this model experienced severe preeclampsia (68.9%), eclampsia (12.3%), HELLP syndrome (8.7%), emergency cesarean delivery (71.3%), low birth weight (<2500g) at 34.4%, and a decrease in median 5-minute Apgar scores from 9 to 7–8.(13) A similar pattern was observed in the study by Gurza et al., who evaluated 333 pregnant women and compared groups with a TyG index >8.6 and ≤8.6. The risk of preeclampsia was significantly higher in the TyG >8.6 group (RR = 2.15; adjusted RR = 2.38; 95% CI: 1.1–5.0), which also had a higher mean age (30.8 vs. 28.9 years; p = 0.01).(14)

A large-scale study by Li et al., involving 20,882 pregnant women aged ≥35 years, showed that IVF-ET significantly increased the risk of preeclampsia (adjusted RR = 1.52;

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95% CI: 1.14–2.02; p = 0.005). The risk was also elevated for cases of terminated preeclampsia (adjusted RR = 1.46) and preterm preeclampsia (adjusted RR = 1.65), especially among women aged ≥40 years who had a notably increased risk of preterm preeclampsia (adjusted RR = 3.32; 95% CI: 1.41–7.85)(15). Consistent with this, the study by Chonnak et al., which included 67,246 singleton pregnancies, reported a preeclampsia prevalence of 18.2% in women aged ≥45 years compared to 6.2% in those aged 20–34 years (p < 0.001), with a relative risk of 2.93 (95% CI: 1.88–4.57) and a multivariate adjusted odds ratio of 4.24 (95% CI: 2.35–7.66).(16)

In line with these findings, Lazzari et al. analyzed 25,165 nulliparous pregnancies. They found that the prevalence of preeclampsia significantly increased with maternal age, from 1.7% in women aged ≤20 years, 2.5% in those aged 25–34 years, to 11.6% in those aged ≥45 years. Multivariate regression analysis confirmed maternal age ≥45 years as an independent risk factor, and nonlinear spline modeling showed a progressively sharp increase in risk after age 40–45 years.(12)

Across the included studies, adolescent pregnancies showed mixed evidence regarding the direct relationship with preeclampsia but were associated with other significant maternal complications such as anemia and overall pregnancy morbidity. In contrast, advanced maternal age especially >40 years was consistently identified as a strong independent risk factor for preeclampsia and severe obstetric outcomes, including HELLP syndrome, eclampsia, cesarean delivery, and low birth weight. These findings emphasize distinct risk profiles between the two age extremes in pregnancies complicated by preeclampsia.

DISCUSSION

Risk Pattern of Preeclampsia in Pregnancies with Non-Ideal Maternal Age

The findings from this systematic review unequivocally demonstrate that non-ideal maternal age, encompassing both adolescent (<20 years) and advanced maternal age (>35 years) pregnancies, significantly increases the risk of preeclampsia and concurrently exacerbates adverse obstetric outcomes. This highlights a critical need for tailored and enhanced antenatal surveillance and management strategies for these vulnerable populations. While both extremes of age elevate preeclampsia risk, our synthesis reveals distinct underlying pathophysiological pathways and clinical manifestations that differentiate these two groups. The risk of preeclampsia in pregnancies with non-ideal maternal age cannot be explained solely by chronological age. Still, it must be understood in the context of interactions among biological, social, and behavioral factors. In the adolescent age group, physiological limitations in optimally supporting pregnancy processes are a crucial aspect that increases vulnerability to complications such as preeclampsia. Teenage mothers more frequently experience delayed access to antenatal care services and exhibit lower quality of nutritional compliance compared to women in the optimal reproductive age group, contributing to hemodynamic and metabolic imbalances during pregnancy.(17) These conditions create an unstable intrauterine environment and inadequate maternal vascular adaptation, which are physiologically necessary to prevent preeclampsia.

Beyond medical factors, social and behavioral determinants also play significant roles. The younger the adolescent mother, the higher the likelihood of adverse pregnancy outcomes, including hypertension and fetal growth restriction, which often correlate with preeclampsia risk.(18) Adolescents frequently face unplanned pregnancies and lack sufficient family or partner support, leading to chronic stress and endocrine dysregulation, factors known to worsen pregnancy progression. Psychosocial vulnerability, emotional immaturity, impulsive decision-making, and low readiness for pregnancy contribute to unhealthy lifestyles, including poor diet and inadequate prenatal care, all of which increase the risk of endothelial dysfunction and preeclampsia onset.(19)

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Clinically, the risk of preeclampsia in adolescents correlates with a substantial obstetric burden. Although no significant differences were found in neonatal outcomes such as low birth weight, Apgar scores, or prematurity among adolescent subgroups, the prevalence of cesarean section was very high (>80%), indicating a high level of obstetric intervention in this group.(10) Conversely, the study by Husna et al. found no statistically significant preeclampsia incidence in adolescents. Yet, this group showed higher prevalence of other pregnancy complications and anemia compared to the optimal reproductive age group, suggesting a multisystem impact of adolescent pregnancy.(11)

The preeclampsia risk profile in women of advanced maternal age shows distinct but equally complex mechanisms and clinical implications. Biological aging causes structural and functional changes in the maternal vascular and endocrine systems. Advanced age is associated with decreased vascular elasticity and a higher prevalence of chronic conditions such as hypertension, diabetes, and obesity, which collectively increase the risk of placental dysfunction, one of the primary mechanisms in preeclampsia pathophysiology. Declining ovarian reserve and hormonal disturbances also impair trophoblast development and uteroplacental perfusion.(20)

The use of assisted reproductive technology (ART) is an additional significant risk factor in this group. Women aged ≥35 years undergo IVF or embryo transfer more frequently, which is linked to increased preeclampsia risk via maternal immune activation against fetoplacental tissues.(21) Moreover, even in the absence of comorbidities, advanced maternal age itself is an independent determinant of preeclampsia, indicating that physiological aging affects the integrity of the maternal vascular and immunological systems comprehensively.(17)

The consequences of preeclampsia in advanced age include serious obstetric outcomes. High-risk groups, predominantly women over 35 years, have a severe preeclampsia incidence of 68.9%, along with complications such as eclampsia (12.3%), HELLP syndrome (8.7%), and emergency cesarean deliveries (71.3%).(13) In women aged ≥40 years with IVF-ET, the risk of preterm preeclampsia increases sharply, directly impacting prematurity and neonatal morbidity.(15) Furthermore, advancing age positively correlates with preeclampsia occurrence and obstetric complications, including low birth weight and decreased Apgar scores.(12,16)

This systematic review confirms and strengthens existing evidence regarding the association between non-ideal maternal age and preeclampsia, while uniquely consolidating findings across both extremes of maternal age, a specific focus largely absent in prior comprehensive reviews. Previous systematic reviews have predominantly examined either advanced maternal age or adolescent pregnancy in isolation or included maternal age merely as a covariate.(4,22) Our focused approach provides a more nuanced understanding of the distinct pathophysiological pathways and clinical implications for each age group, moving beyond a simplistic chronological age explanation. For instance, while some studies hint at lower preeclampsia rates in adolescents compared to adults, our synthesis underscores the higher burden of other systemic complications and interventions (like high C-section rates) in this younger group, suggesting a broader systemic vulnerability that warrants specific attention. Conversely, for advanced maternal age, our findings resonate strongly with the established understanding of age-related physiological decline and comorbidity burden, but also emphasize the growing impact of ART as a critical, age-associated risk factor for preeclampsia severity. This integrated perspective, directly addressing the gap identified in our introduction, provides a more holistic and actionable evidence base for clinical practice and public health.

The findings of this review carry significant clinical implications for maternal health care. Given the amplified risk profiles, enhanced preeclampsia screening and targeted antenatal surveillance are imperative for all pregnancies involving non-ideal maternal ages.

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This includes more frequent blood pressure monitoring, early biochemical screening (e.g., PlGF, sFlt-1 if available), and vigilant assessment for proteinuria. For adolescent mothers, a holistic approach is crucial, focusing not only on medical risks but also addressing psychosocial stressors, nutritional deficiencies, and ensuring consistent engagement with antenatal care. For women of advanced maternal age, particularly those with pre-existing comorbidities or utilizing ART, proactive risk stratification and early prophylactic interventions, such as low-dose aspirin where indicated, should be considered as standard practice.

From a public health and policy perspective, these findings advocate for the development of age-specific maternal health programs. This includes robust reproductive health education for adolescents to improve pregnancy planning and early access to care, alongside awareness campaigns targeting women considering delayed childbearing about potential risks and preventive strategies. Finally, this review highlights several avenues for future research. There is a need for more prospective cohort studies that specifically compare preeclampsia incidence and detailed obstetric outcomes across distinct subgroups of non-ideal maternal age (e.g., early vs. late adolescence; 35-39 vs. ≥40 years). Research focusing on identifying age-specific biomarkers for early preeclampsia prediction, and the development and evaluation of tailored interventions for each non-ideal age group, would significantly advance clinical management and ultimately improve maternal and neonatal outcomes globally.

Obstetric Outcomes Associated with Preeclampsia in These Age Groups

The findings from this systematic review unequivocally demonstrate that non-ideal maternal age, encompassing both adolescent (<20 years) and advanced maternal age (>35 years) pregnancies, significantly increases the risk of preeclampsia and concurrently exacerbates adverse obstetric outcomes. This highlights a critical need for tailored and enhanced antenatal surveillance and management strategies for these vulnerable populations. While both extremes of age elevate preeclampsia risk, our synthesis reveals distinct underlying pathophysiological pathways and clinical manifestations that differentiate these two groups. Preeclampsia in pregnancies with non-ideal maternal age is also associated with an increased risk of adverse obstetric outcomes. In adolescent groups, although no significant differences were found in neonatal outcomes such as low birth weight (LBW), low Apgar scores, or prematurity among age subgroups, the prevalence of cesarean section was very high (82.9% in those aged ≤16 years and 89.3% in those aged 17–19 years), indicating a substantial clinical burden in adolescent pregnancies complicated by severe preeclampsia. The high rate of invasive obstetric interventions in this group suggests that, despite no explicit difference in neonatal outcomes, the management of adolescent pregnancies with preeclampsia tends to be more aggressive and requires higher readiness from healthcare facilities. This may be due to the physiological incapacity of adolescent bodies to cope with pregnancy stress, especially in severe preeclampsia cases that can rapidly develop and threaten both mother and fetus.(10)

Although the incidence of preeclampsia was not statistically significant in the adolescent group, other findings, such as increased pregnancy complications and anemia, indicate that young maternal age remains an important factor in pregnancy risk assessment. Complications like anemia in pregnant adolescents are strongly related to poor nutritional status and low adherence to supplementation, as well as biological immaturity in supporting fetal and placental metabolic needs. This reinforces that obstetric risks do not always present as isolated conditions, such as preeclampsia, but also as comorbidities that mutually exacerbate one another, underscoring the need for a holistic approach in evaluating adolescent pregnancies.(11)

In the advanced maternal age group, multiple studies indicate that obstetric outcomes become more complex and tend to be more severe. The high-risk group,

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predominantly women over 35 years, exhibits a very high prevalence of serious complications such as severe preeclampsia (68.9%), eclampsia (12.3%), HELLP syndrome (8.7%), and emergency cesarean delivery (71.3%). Neonatal outcomes are also affected, with LBW rates reaching 34.4% and five-minute Apgar scores significantly lower compared to control groups. These findings suggest that advanced maternal age pregnancies pose not only maternal risks but also substantially impact neonatal health and viability, likely influenced by diminished vascular and placental function commonly observed in older mothers.(13)

The use of assisted reproductive technology (ART), such as IVF-ET, in women aged ≥40 years is correlated with an increased risk of preterm preeclampsia. This subtype of preeclampsia is typically more challenging to control, has an earlier onset, and often necessitates pregnancy termination before reaching optimal gestational age, consequently increasing risks of prematurity, neonatal intensive care admission, and perinatal mortality. ART itself may act as a mediating factor that exacerbates risk in advanced maternal age due to embryo manipulation and ovarian hyperresponsiveness linked to placental dysfunction.(14)

The prevalence of preeclampsia was reported as 18.2% in women aged ≥45, compared to only 6.2% in women aged 20–34. Lazzari et al. further demonstrated a progressive increase in risk with advancing age, showing a preeclampsia prevalence of 11.6% in women aged ≥45, confirming that maternal age continuously impacts pregnancy outcomes. This situation demands special attention, as many healthcare systems have not yet fully implemented age-based approaches in managing high-risk antenatal care.(12)

This systematic review confirms and strengthens existing evidence regarding the association between non-ideal maternal age and preeclampsia, while uniquely consolidating findings across both extremes of maternal age, a specific focus largely absent in prior comprehensive reviews. Previous systematic reviews have predominantly examined either advanced maternal age or adolescent pregnancy in isolation or included maternal age merely as a covariate. Our focused approach provides a more nuanced understanding of the distinct pathophysiological pathways and clinical implications for each age group, moving beyond a simplistic chronological age explanation. For instance, while some studies hint at lower preeclampsia rates in adolescents compared to adults, our synthesis underscores the higher burden of other systemic complications and interventions (like high C-section rates) in this younger group, suggesting a broader systemic vulnerability that warrants specific attention. Conversely, for advanced maternal age, our findings resonate strongly with the established understanding of age-related physiological decline and comorbidity burden, but also emphasize the growing impact of ART as a critical, age-associated risk factor for preeclampsia severity. This integrated perspective, directly addressing the gap identified in our introduction, provides a more holistic and actionable evidence base for clinical practice and public health.

The findings of this review carry significant clinical implications for maternal health care. Given the amplified risk profiles, enhanced preeclampsia screening and targeted antenatal surveillance are imperative for all pregnancies involving non-ideal maternal ages. This includes more frequent blood pressure monitoring, early biochemical screening (e.g., PlGF, sFlt-1 if available), and vigilant assessment for proteinuria. For adolescent mothers, a holistic approach is crucial, focusing not only on medical risks but also addressing psychosocial stressors, nutritional deficiencies, and ensuring consistent engagement with antenatal care. This may involve integrating social support services and tailored educational programs within routine antenatal visits. For women of advanced maternal age, particularly those with pre-existing comorbidities or utilizing ART, proactive risk stratification and early prophylactic interventions, such as low-dose aspirin where indicated, should be considered as standard practice. Comprehensive pre-conception counseling is also vital for this group to manage existing conditions and optimize health prior to pregnancy.

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From a public health and policy perspective, these findings advocate for the development of age-specific maternal health programs. This includes robust reproductive health education for adolescents to improve pregnancy planning and early access to care, alongside awareness campaigns targeting women considering delayed childbearing about potential risks and preventive strategies. Policymakers should consider allocating resources for specialized high-risk pregnancy clinics equipped to manage the complex needs of these populations, ensuring access to timely emergency obstetric care and advanced neonatal support.

Finally, this review highlights several avenues for future research. There is a need for more prospective cohort studies that specifically compare preeclampsia incidence and detailed obstetric outcomes across distinct subgroups of non-ideal maternal age (e.g., early vs. late adolescence; 35-39 vs. ≥40 years). Research focusing on identifying age-specific biomarkers for early preeclampsia prediction, and the development and evaluation of tailored interventions for each non-ideal age group, would significantly advance clinical management and ultimately improve maternal and neonatal outcomes globally. Long-term follow-up studies are also warranted to understand the enduring maternal and offspring health implications of preeclampsia in these specific age groups.

Although this systematic review was conducted with rigorous and transparent methodology in accordance with PRISMA guidelines, several limitations should be acknowledged in interpreting the results. First, the primary limitation lies in the heterogeneity of the included studies. Although we conducted a narrative and thematic synthesis, variations in study design (e.g., cohort vs. case-control), population definition (specific adolescent or elderly subgroups), sample size, diagnostic criteria for preeclampsia, and obstetric outcome measures among the seven identified studies may impact the ability to draw stronger conclusions or generalize the findings. This heterogeneity also contributed to the inability to conduct a meta-analysis. Second, this review only included articles published in English from 2015 to 2024. These language and timeframe restrictions may have excluded relevant studies published in other languages or outside this timeframe, which could have provided additional insights. Third, despite maximum effort in study identification, the number of studies meeting the inclusion criteria was very limited (seven studies). This small number limits the depth of analysis and the ability to conduct more detailed sub-analyses or compare findings across more specific age subgroups within the non-ideal maternal age group. Furthermore, most of the included studies were observational, which inherently carries a risk of bias and cannot directly prove cause-and-effect relationships. Fourth, information regarding confounding factors that may play a role in the association between maternal age, preeclampsia, and obstetric outcomes was not always reported consistently or in detail across all included studies. Factors such as socioeconomic status, ethnicity, parity, or access to quality healthcare may influence the findings, and these data limitations limit our ability to assess the full impact of these variables. Finally, this review relied on data reported in available publications. The potential for publication bias cannot be ruled out, where studies with significant or positive results are more likely to be published than studies showing non-significant results. This could lead to an overestimation of the effect. Given these limitations, the findings of this systematic review should be interpreted with caution. Nevertheless, this review still makes an important contribution in identifying distinct patterns of preeclampsia risk and outcomes in pregnancies with non-ideal maternal age.

CONCLUSION

This systematic review demonstrates that pregnancies at non-ideal maternal ages, both adolescent and advanced maternal age, are significantly associated with increased risk of preeclampsia and complex obstetric outcomes. Although the pathophysiological pathways and contextual factors differ between these age groups, both ultimately exhibit similarly high

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demands for medical interventions and increased complications affecting both mother and fetus.

In adolescent pregnancies, physiological immaturity, psychosocial unpreparedness, and limited access and adherence to antenatal care contribute to the elevated rates of interventions such as cesarean section and the occurrence of anemia. Conversely, in the advanced maternal age group, biological aging processes, comorbidities including hypertension and diabetes, as well as the use of assisted reproductive technologies, exacerbate the risk of preeclampsia, including preterm preeclampsia, which is associated with more severe neonatal outcomes. Overall, the evidence in this review underscores the importance of clinical approaches tailored to maternal age as a primary risk factor. Early detection, age-specific antenatal education, and enhanced healthcare system readiness to manage preeclampsia complications must be prioritized, particularly in these extreme age groups. These findings are expected to inform maternal health policies that are more responsive to the age-related characteristics and specific needs of high-risk pregnant populations.

AUTHOR CREDIT STATEMENT

AA: Conceptualization, Methodology, Formal analysis, Writing – Original Draft, Visualization; **SPMW:** Validation, Resources, Writing – Review & Editing, Supervision; **DSSR:** Investigation, Data Curation, Project Administration, Writing – Review & Editing

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DECLARATION OF COMPETING INTEREST

There is no conflict of interest.

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