

Systematic Review

Association Between Age at Menarche and the Risk of Preeclampsia in Pregnant Women: A Systematic Review and Meta-analysis

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Abstract

Objective: This study aimed to examine the association between age at menarche and the risk of preeclampsia.

Methods: This study followed the PRISMA 2020 guidelines. A literature search was conducted in PubMed, Scopus, Cochrane Library, EBSCOhost, and SAGE Journals up to November 13, 2025. Observational studies assessing age at menarche and preeclampsia were included. Risk of bias was evaluated using the Newcastle-Ottawa Scale. Data were pooled using a random-effects inverse-variance model to estimate Odds Ratios (ORs) with 95% Confidence Intervals (CIs). Heterogeneity, subgroup analysis, meta-regression, sensitivity analyses, and publication bias were performed.

Results: Eight studies involving 219,933 participants with a low to moderate risk of bias were included. The analysis showed a higher risk of preeclampsia in early menarche compared to normal menarche (OR 2.84, 95% CI 1.64–4.93; $p < 0.000$; $I^2 = 95\%$), normal menarche compared to late menarche (OR 1.56, 95% CI 1.14–2.15; $p = 0.006$; $I^2 = 65\%$), and early menarche compared to late menarche (OR 2.40, 95% CI 1.40–4.11; $p = 0.001$; $I^2 = 84\%$).

Conclusion: Age at menarche is associated with the risk of preeclampsia. However, the findings should be interpreted with caution due to several limitation.

Keywords: Age at menarche; hypertension in pregnancy; preeclampsia; pregnancy

Hubungan antara Usia Menarche dan Risiko Preeklampsia pada Ibu Hamil: Tinjauan Sistematis dan Meta-analisis

Abstrak

Tujuan: Penelitian ini bertujuan untuk mengevaluasi hubungan antara usia menarche dengan risiko preeklampsia.

Metode: Penelitian ini mengikuti pedoman PRISMA 2020. Pencarian literatur dilakukan pada basis data PubMed, Scopus, Cochrane Library, EBSCOhost, dan SAGE Journals hingga 13 November 2025. Studi observasional yang menilai hubungan antara usia menarche dan preeklampsia diikutsertakan. Risiko bias dinilai menggunakan Skala Newcastle-Ottawa. Analisis data dilakukan dengan model efek acak metode varians terbalik untuk menghitung Odds Ratio (OR) dengan 95% Confidence Interval (CI). Heterogenitas, analisis subkelompok, meta-regresi, analisis sensitivitas, serta bias publikasi juga dianalisis.

Hasil: Delapan studi dengan total 219.933 partisipan dengan risiko bias rendah hingga sedang diikutsertakan. Analisis menunjukkan bahwa risiko preeklampsia lebih tinggi pada menarche dini dibandingkan menarche normal (OR 2.84, 95% CI 1.64–4.93; $p < 0.000$; $I^2 = 95\%$), menarche normal dibandingkan menarche lambat (OR 1.56, 95% CI 1.14–2.15; $p = 0.006$; $I^2 = 65\%$), serta menarche dini dibandingkan menarche lambat (OR 2.40, 95% CI 1.40–4.11; $p = 0.001$; $I^2 = 84\%$).

Kesimpulan: Usia menarche berhubungan dengan risiko preeklampsia. Namun, hasil ini perlu diinterpretasikan secara hati-hati karena beberapa keterbatasan.

Kata Kunci: Hipertensi dalam kehamilan; kehamilan; preeklampsia; usia menarche

Introduction

Preeclampsia continues to be a major contributor to maternal and perinatal morbidity and mortality. Globally, the condition affects approximately 2-8% of all pregnancies and contributes to an estimated 46,000 maternal and 500,000 perinatal deaths each year.¹ The burden is considerably higher in developing countries, with prevalence ranging from 1.3-6% in developed countries and 1.8-18% in developing countries.² In Indonesia, preeclampsia is estimated to occur in approximately 128,273 pregnancies annually, representing about 5.3% of all pregnancies.³ Preeclampsia also contributes substantially to adverse maternal and neonatal outcomes, accounting for approximately 1.6% of maternal deaths, as well as perinatal mortality rates of 5.7% among fetuses and 6.1% among neonates.⁴

Preeclampsia is defined as new-onset hypertension after 20 weeks of gestation accompanied by proteinuria or other signs of organ dysfunction.⁵ Although the clinical manifestations of the disorder are well described, its underlying pathogenesis and pathophysiology remain complex and not fully understood. Current evidence suggests that preeclampsia results from impaired placental development, followed by systemic endothelial dysfunction and inflammatory response. These processes ultimately lead to the clinical manifestations of the disorder, including hypertension, proteinuria, and organ dysfunction.⁶

Increasing attention has been directed toward biological factors originating earlier in life that may influence susceptibility to preeclampsia. Among these factors, age at menarche has emerged as an important indicator of reproductive maturation. Age at menarche reflects the complex interplay of genetic, environmental, nutritional, and metabolic influences that shape reproductive development.⁷ Early menarche has been

associated with increased adiposity and insulin resistance, which may contribute to long-term metabolic and endocrine dysregulation.⁸ This dysregulation can lead to endothelial dysfunction, a key mechanism in the pathogenesis of preeclampsia.⁶

Studies investigating the association between age at menarche and the risk of preeclampsia have yielded inconsistent findings, and the available evidence remains limited. In addition, most existing studies are observation in nature and use different categorizations of age at menarche, reflecting the absence of a standardized definition, which may contribute to heterogeneity across studies. To date, no systematic review and meta-analysis have comprehensively synthesized this association. Therefore, this study aimed to examine the association between age at menarche and the risk of preeclampsia in pregnant women.

Methods

This study followed the PRISMA 2020 reporting guidelines⁹ and was prospectively registered in PROSPERO (CRD420261370605).

Inclusion and Exclusion Criteria

The inclusion criteria comprised peer-reviewed original research articles with cohort, case-control, or cross-sectional study designs involving pregnant women, published in English or Indonesian. The exposure and comparison were age at menarche, categorized into early, normal, and late menarche, although the categorization thresholds varied across studies. To reduce heterogeneity, only studies that clearly classified participants into these categories were included. The outcome was preeclampsia, defined as new-onset hypertension (systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg) after 20 weeks of gestation,

accompanied by proteinuria or other signs of organ dysfunction.⁵ The exclusion criteria consisted of incomplete or inaccessible texts and outcomes in which preeclampsia could not be distinguished from other hypertensive disorders in pregnancy.

Search Strategy

A literature search was conducted in PubMed, Scopus, Cochrane Library, EBSCOhost, and SAGE Journals on November 13, 2025. The search strategy integrated Medical Subject Headings (MeSH) and entry terms identified from the MeSH database based on the PECO framework, covering the concepts of women (“Woman,” “Girl,” and “Women’s Group”), pregnancy (“Gestation”), pregnant people (“Pregnant Person” and “Pregnant Woman”), menarche (“Menarche”), and pre-eclampsia (“Preeclampsia,” “Pregnancy Toxemia,” “Edema-Proteinuria-Hypertension Gestosis,” “EPH Complex,” “EPH Toxemia,” “EPH Gestosis,” “Toxemia Of Pregnancy,” and “Preeclampsia Eclampsia”). The search terms were combined using the Boolean operators “OR” and “AND”. Filters or limits were not applied, and additional searches were not conducted in trial registries or other sources.

Study Selection

The study selection was performed using Rayyan through a two-stage screening process conducted independently and blindly by three reviewers. In the first stage, titles and abstracts were examined according to the PECO framework. The second stage consisted of a full-text assessment based on the inclusion and exclusion criteria. In the event of disagreements during the selection process, the final decision was reached through discussion. The entire process of search strategies and study selection is illustrated in the PRISMA 2020 flow diagram.⁹

Quality Assessment

The risk of bias was independently assessed by three reviewers using the Newcastle Ottawa Scale (NOS). The original NOS was used for cohort and case-control study designs, evaluating selection, comparability, and outcome or exposure domains,¹⁰ while a modified NOS was used for cross-sectional studies, assessing sample selection, measurement of exposure and outcome, and control of confounding.¹¹ Each study received a score ranging from 0 to 9 and was categorized as high quality (7-9 stars, low risk of bias), moderate quality (4-6 stars, moderate risk of bias), or low quality (0-3 stars, high risk of bias).¹⁰ The certainty of evidence was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach and the strength of recommendations was categorized as strong or weak/conditional based on the balance of evidence.¹²

Data Extraction

The data extraction was independently performed by three reviewers using a predefined form to systematically collect details for each study, including author, year, study design, country, study period, population, sample size, categorization of age at menarche, definition of preeclampsia, and the number of preeclampsia and non-preeclampsia cases. Countries were classified into high-income and non-high-income groups based on the World Bank income classification¹³. When multiple results were reported within a study, the most relevant data were selected based on the predefined criteria. Missing or unclear data were not imputed. Data were recorded and managed using Microsoft Excel.

Statistical Analysis

Statistical analyses were performed using Review Manager version 5.4 and RStudio software. Data were extracted into 2×2 tables, and comparisons were conducted between early and normal, late and normal, and early and late menarche. The pooled effect was reported as Odds Ratios (ORs) with 95% Confidence Intervals (CIs), calculated using the inverse-variance method under a random-effects model based on the DerSimonian-Laird approach. Statistical heterogeneity was evaluated using the Chi-square (χ^2) test and the I^2 statistic, with the degree of heterogeneity interpreted as 0-40% (not important), 30-60% (moderate), 50-90% (substantial), and 75-100% (considerable).

Publication bias was assessed through visual inspection of funnel plot asymmetry. Subgroup analyses were performed to examine potential differences in effect

estimates across study characteristics by stratifying the studies. Meta-regression analysis was conducted using a weighted least squares approach under a random-effects model, incorporating between-study variance (τ^2), to assess the impact of age at menarche categorization on heterogeneity among the included studies. Sensitivity analyses were conducted to assess the stability of the pooled effect by sequentially removing individual studies and by varying the statistical model.

Results

Search Strategies and Study Selection

A total of 546 records were identified from PubMed (n = 62), Scopus (n = 175), Cochrane Library (n = 3), EBSCOhost (n = 59), and SAGE Journals (n = 247). After removing 106 duplicates, 440 studies remained for the

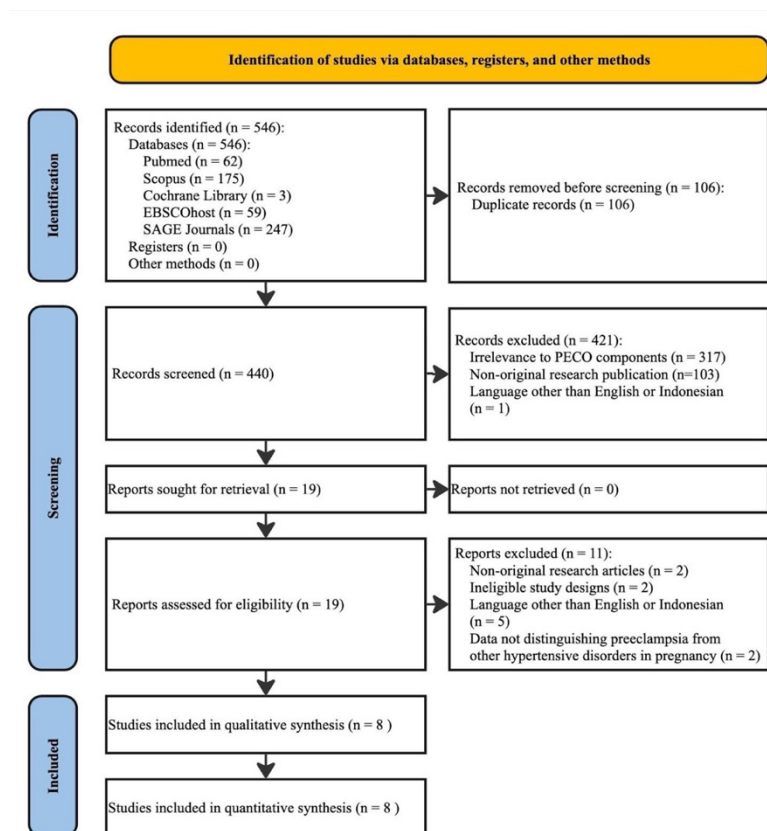


Figure 1 PRISMA 2020 Flow Diagram

first selection stage. The first selection stage excluded 421 studies, leaving 19 articles in the second selection stage. The second selection stage excluded 11 studies, which consisted of 2 non-original research articles, 2 studies with ineligible study designs, 5 studies published in language other than English or Indonesian, and 2 studies that did not distinguish preeclampsia from other hypertensive disorders in pregnancy. Consequently, eight studies were included in this study (Figure 1).

Characteristic of the Included Studies

The characteristics of the included studies are presented in Table 2. The included studies comprised three cohort, four case-control, and one cross-sectional studies conducted between 1993 and 2022 in high-income countries (United States^{14,15} and Finland¹⁶) and non-high-income countries (China,^{17,18} India,¹⁹ and Ethiopia^{20,21}). Sample sizes ranged from 261 to 209,411 participants. The study populations included pregnant women from both population-based and hospital-based settings. Across studies, the categorization of age at menarche varied, with early menarche defined between ≤ 11 and ≤ 15 years, normal menarche between 12 and 16 years, and late menarche between ≥ 14 and ≥ 17 years. All studies applied a consistent definition of preeclampsia.

The number of preeclampsia cases ranged from 17 to 540 in the early menarche group, 16 to 4,170 in the normal menarche group, and 8 to 599 in the late menarche group. Data on late menarche were not available in all studies, as some studies categorized menarche into only two groups. The risk of bias ranged from moderate to high across studies, with most studies rated as high quality with scores of 8-9, one study as moderate quality with a score of 6, and none as low quality. The overall risk of bias among the included studies was low to moderate.

Comparison Between Early and Normal Menarche

Eight studies including 20,722 and 170,378 participants were analyzed in the early and normal menarche groups. Higher effect estimates were observed across all studies, with 75% (6/8) reaching statistical significance. The pooled analysis showed an increased risk of preeclampsia in the early menarche group (OR 2.84, 95% CI 1.64–4.93; $p < 0.000$), with considerable heterogeneity ($I^2 = 95\%$) (Figure 2). Subgroup analysis revealed significant differences according to study design ($p = 0.01$) and income level ($p = 0.02$) (Table 2). Meta-regression did not identify statistically significant associations (Table 3). Sensitivity analysis showed consistent and significant results after removing individual studies and variation of the statistical model. Funnel plot inspection indicated asymmetry.

Comparison Between Normal and Late Menarche

Five studies comprising 169,780 and 28,833 participants were included in the normal and late menarche groups. Most studies (80%, 4/5) demonstrated higher effect estimates in the normal menarche group, with 60% (3/5) reaching significance. The pooled estimate indicated a higher risk of preeclampsia among women with normal menarche compared to those with late menarche (OR 1.56, 95% CI 1.14–2.15; $p = 0.006$). Heterogeneity was moderate ($I^2 = 65\%$) (Figure 2). Subgroup analysis showed significant differences according to study design ($p = 0.001$) and income level ($p = 0.003$) (Table 2). Meta-regression did not identify statistically significant associations (Table 3). Sensitivity analysis showed consistent and significant results and the funnel plot indicated asymmetry.

Table 1 Study Characteristics

Author, Year	Study Design	Country, Study Period	Sample Size	Age of Menarche				Number of Cases				Risk of Bias	
				Early		Late		Early		Normal			
				Early	Normal	Late	PE	PE	No PE	PE	No PE		
Rudra and William, 2005	Case-control	United States (1998-2002)	757	≤11	12-13	≥14	59	83	181	256	43	124	8/9 (High)
Abetew et al., 2011	Cohort	United States (1996- 2008)	3,365	≤11	12-14	≥15	17	464	55	2,342	8	442	9/9 (High)
Ramesh et al., 2014	Case-control	India (2013)	300	≤11	≥12	-	84	57	16	143	-	-	6/9 (Moderate)
Jaatinen et al., 2021	Case-control	Finland (2008-2011)	1,432	≤10	11-15	≥16	29	14	650	669	9	25	8/9 (High)
Ayele and Tilahun, 2022b	Cross-sectional	Ethiopia (2020-2021)	261	≤15	≥16	-	20	23	21	197	-	-	8/9 (High)
Ayele and Tilahun, 2022b	Case-control	Ethiopia	264	≤15	≥15	-	30	13	58	163	-	-	8/9 (High)
An et al., 2023	Cohort	China (1993-1996)	209,411	≤13	14-16	≥17	540	18,319	4,170	158,660	599	27,123	8/9 (High)
Cheng et al., 2023	Cohort	China (2021-2022)	4,227	≤12	13-14	≥15	127	843	161	2,636	18	442	8/9 (High)

* PE: preeclampsia; No PE: no preeclampsia; Age of menarche presented in years.

Comparison Between Early and Late Menarche

Five studies including 20,495 and 28,833 women were analyzed in the early and late menarche groups. All studies showed higher effect estimates in the early menarche group, with 60% (3/5) reaching statistical significance. The pooled analysis showed an increased risk of preeclampsia associated with early menarche (OR 2.40, 95% CI 1.40–4.11; $p = 0.001$), with substantial heterogeneity ($I^2 = 84\%$) (Figure 2). Subgroup analysis showed no significant differences according to study design ($p = 0.75$) or income level ($p = 0.45$) (Table 2). Meta-regression identified a significant association for the definition of late menarche ($\beta = 0.808$; $p = 0.011$) (Table 3). Sensitivity analysis showed consistent and significant results. Funnel plot inspection indicated asymmetry.

Certainty of Evidence

The certainty of evidence was rated as low, primarily due to the observational study design, heterogeneity, and publication bias. Therefore, the findings correspond to a weak/conditional interpretation.

Discussion

This study evaluated the association between age at menarche and the risk of preeclampsia across three comparisons. The findings suggest a consistent gradient pattern, in which early menarche was associated with the highest risk of preeclampsia, followed by normal menarche, while late menarche showed the lowest risk. This gradient pattern indicates that age at menarche may serve as an early-life marker of susceptibility rather than a direct causal factor. It reflects underlying

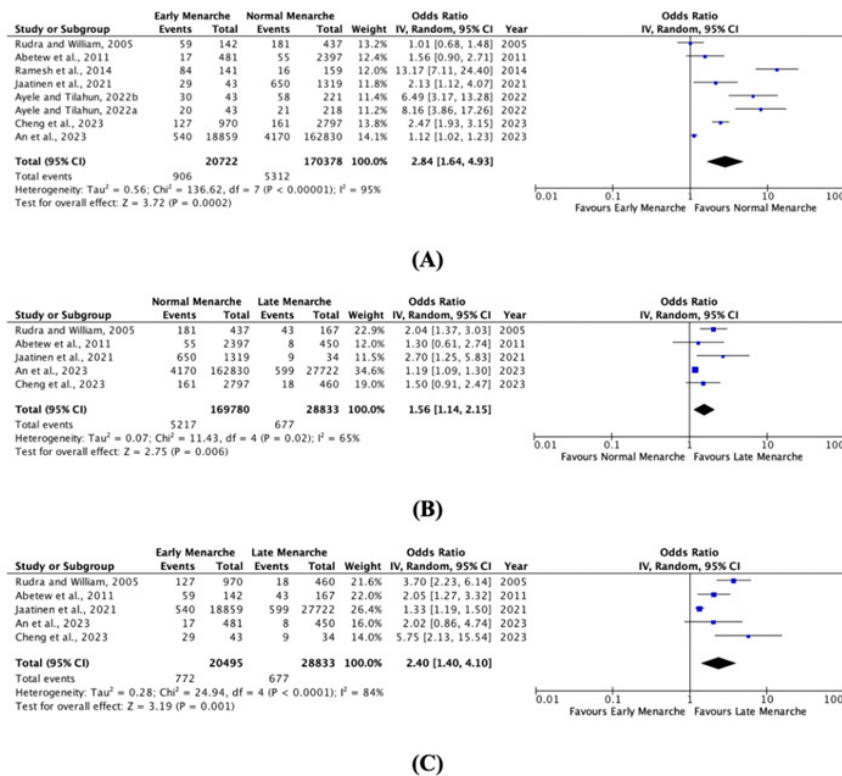


Figure 2 Forest Plots: (A) Early and Normal Menarche, (B) Normal and Late Menarche, and (C) Early and Late Menarche

Table 2 Subgroup Analysis

Comparison	Subgroup	Category	OR (95% CI)	I ² (%)	p-value
Early and Normal Menarche	Study design	Cohort	1.62 (0.89–2.95)	94	0.01
		Case-control	3.83 (1.06–13.86)	95	
		Cross-sectional	6.49 (3.17–13.28)	NA	
	Income	High income	1.41 (0.90–2.20)	54	0.02
		Non-high-income	4.31 (1.87–9.92)	97	
Normal and Late Menarche	Study design	Cohort	1.20 (1.10–1.31)	0	0.001
		Case-control	2.16 (1.52–3.07)	0	
		High income	1.97 (1.43–2.71)	0	0.003
	Income	Non-high-income	1.20 (1.10–1.30)	0	
		High income	2.59 (1.46–4.59)	44	
Early and Late Menarche	Study design	Cohort	2.15 (0.79–5.84)	93	0.75
		Case-control	2.09 (1.12–3.87)	88	
		Non-high-income	3.30 (1.19–9.17)	59	
	Income	High income	2.09 (1.12–3.87)	88	0.45
		Non-high-income	3.30 (1.19–9.17)	59	

Table 3 Meta-regression Analysis

Variables	Early and Normal Menarche		Normal and Late Menarche		Early and Late Menarche	
	β	p-value	β	p-value	β	p-value
Categorization of Early Menarche	0.270	0.489	0.037	0.821	-0.135	0.350
Categorization of Late Menarche	0.442	0.342	0.294	0.218	0.808	0.011

biological and developmental mechanisms that influence the risk of preeclampsia.

Currently, no systematic review and meta-analysis has specifically examined this association. However, evidence from the included studies consistently supports these findings, demonstrating a dose-response pattern, with decreasing age at menarche associated with progressively higher risk of hypertensive disorders during pregnancy, including preeclampsia.^{14,17,18} Consistent with this finding, a cohort study from the United Kingdom reported that each one-year decrease in age at menarche was associated with higher mean arterial pressure in late pregnancy.²²

The mechanisms underlying this association are not fully established, although several biological pathways have been implicated. Early menarche reflects earlier activation of the hypothalamic-pituitary-

ovarian (HPO) axis,⁷ resulting in prolonged exposure to reproductive hormones. This condition is accompanied by increased body fat accumulation from childhood, contributing to adiposity and insulin resistance. These metabolic alterations lead to chronic metabolic and endocrine dysregulation⁸, leading to subclinical endothelial dysfunction before pregnancy. During pregnancy, this underlying endothelial dysfunction may impair normal uteroplacental vascular adaptation, resulting in abnormal placental perfusion that contributes to the development of preeclampsia.⁶ Furthermore, obesity and metabolic disturbances, including hyperlipidemia, hyperinsulinemia, and hyperglycemia may further exacerbate these processes.^{14,23}

In contrast, late menarche may exert a protective effect against metabolic syndrome²⁴, reflecting a more favorable

cardiometabolic profile. These conditions result in lower levels of inflammation and oxidative stress, thereby preserving endothelial function before pregnancy. During pregnancy, preserved endothelial function may support normal uteroplacental vascular adaptation, which is associated with a lower risk of preeclampsia. Evidence from individual studies supports this association, indicating that increasing age at menarche is associated with a lower risk of preeclampsia. However, this protective effect may not be consistent across all individuals, as it appears to be influenced by adiposity. Specifically, late menarche appears protective among lean women but attenuated or potentially reversed in women with overweight or obesity.¹⁵

Heterogeneity was observed across the included studies, with varying levels across comparisons. Subgroup analyses suggest that study design and country income level may have contributed to heterogeneity in the comparisons between early and normal menarche and between normal and late menarche, but not in the comparison between early and late menarche. Meta-regression analysis further showed that variations in the categorization of early menarche were not significantly associated with heterogeneity across all comparisons. However, differences in the definition of late menarche contributed to heterogeneity in the comparison between early and late menarche, suggesting that variations in cut-off ages across studies may have influenced the pooled estimates. Overall, these findings indicate that the observed heterogeneity was only partially explained by the analyzed factors and may also reflect additional unmeasured or study-specific sources.

This study has several strengths. It represents the first systematic review and meta-analysis to examine the association between age at menarche and the risk of preeclampsia across multiple comparisons. The use of multiple analytical approaches,

including subgroup analyses, meta-regression, and sensitivity analyses, allowed for a more comprehensive assessment of heterogeneity and robustness. Most included studies were of moderate to high quality, indicating a relatively low to moderate risk of bias. Additionally, the consistent direction of effect across comparisons supports the reliability of the findings.

Nevertheless, several limitations of the included evidence should be acknowledged. Substantial heterogeneity in the operational definitions of age at menarche across studies likely contributed to between-study variability. Thresholds for early menarche ranged from ≤ 10 to ≤ 15 years, whereas definitions of late menarche also varied across studies, potentially introducing exposure misclassification and limiting cross-study comparability. Heterogeneity may also have arisen from differences in population characteristics. In addition, most studies relied on self-reported age at menarche, which is susceptible to recall bias. Adjustment for important confounding factors was inconsistent across studies and may have contributed to residual confounding. Furthermore, the biological and epidemiological significance of age at menarche may vary according to the geographic and temporal contexts.

Limitations of the review process should also be considered. The relatively small number of included studies may have reduced the statistical power and generalizability of the findings. In addition, some studies did not report effect estimates, requiring the use of raw data for the meta-analysis. Searches of trial registries and other grey literature sources were not conducted, which may increase the risk of publication bias. Overall, these limitations should be considered when interpreting the pooled estimates.

The certainty of evidence was rated as low due to the observational study design, heterogeneity, and potential publication

bias. Therefore, the findings should be interpreted with caution. Nevertheless, age at menarche may serve as an early-life marker of preeclampsia risk and may support clinical risk stratification. From a public health perspective, these findings highlight the importance of early-life determinants and support preventive strategies targeting modifiable factors, including nutrition and obesity. Further well-designed prospective studies are needed to clarify this association and its underlying mechanisms.

Conclusion

In conclusion, age at menarche is associated with the risk of preeclampsia, suggesting that it may reflect early-life susceptibility to preeclampsia. However, the findings should be interpreted with caution due to several limitations. Further studies are needed to clarify this association and its underlying mechanisms.

Conflict of Interest

The authors declare no competing interests.

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References

1. World Health Organization. Preeclampsia. Geneva: WHO.
2. Osungbade KO, Ige OK. Public health perspectives of preeclampsia in developing countries: implication for health system strengthening. *J Pregnancy*. 2011;2011:481095.
3. Perkumpulan Obstetri dan Ginekologi Indonesia. Pedoman nasional pelayanan kedokteran: diagnosis dan tatalaksana preeklampsia. Jakarta: POGI; 2016.
4. Aldika Akbar MI, Gumilar KE, Pribadi A, Aziz MA, Ernawati E, Wardhana MP, et al. The Indonesia pre-eclampsia study (INAPRES): pregnancy outcomes in pregnancy with pre-eclampsia in Indonesia. *Int J Gynecol Obstet*. 2025. doi:10.1002/ijgo.70587.
5. American College of Obstetricians and Gynecologists. Gestational hypertension and preeclampsia: ACOG practice bulletin, number 222. *Obstet Gynecol*. 2020;135(6):237–60.
6. Ives CW, Sinkey R, Rajapreyar I, Tita ATN, Oparil S. Preeclampsia—pathophysiology and clinical presentations: JACC state-of-the-art review. *J Am Coll Cardiol*. 2020;76(14):1690–702.
7. Lacroix AE, Gondal H, Shumway KR, Langaker MD. Physiology, menarche [Internet]. Treasure Island: StatPearls Publishing; 2023. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK470216/>
8. Kim JH, Lim JS. Early menarche and its consequence in Korean female: reducing fructose intake could be one solution. *Clin Exp Pediatr*. 2021;64(1):12–20.
9. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71.
10. Wells G, Shea B, O'Connell D, Peterson J, Welch V, Losos M. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses [Internet]. Ottawa: Ottawa Hospital Research Institute; 2014. Available from: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp
11. Carra MC, Romandini P, Romandini M. Risk of bias evaluation of cross-sectional studies: adaptation of the Newcastle-Ottawa Scale. *J Periodontal Res*. 2025.

- doi:10.1111/jre.13405.
12. Prasad M. Introduction to the GRADE tool for rating certainty in evidence and recommendations. *Clin Epidemiol Glob Health*. 2024;25:101484.
 13. Metreau E, Young K, Grace S. World Bank country classifications by income level for 2024–2025 [Internet]. Washington DC: World Bank Data; 2024. Available from: <https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025>
 14. Abetew DF, Enquobahrie DA, Dishu M, Rudra CB, Miller RS, Williams MA. Age at menarche, menstrual characteristics, and risk of preeclampsia. *ISRN Obstet Gynecol*. 2011;2011:1–6.
 15. Rudra CL, Williams MA. BMI as a modifying factor in the relations between age at menarche, menstrual cycle characteristics, and risk of preeclampsia. *Gynecol Endocrinol*. 2005;21(4):200–5.
 16. Jaatinen N, Jääskeläinen T, Laivuori H, Ekholm E. The non-traditional and familial risk factors for preeclampsia in the FINNPEC cohort. *Pregnancy Hypertens*. 2021;23:48–55.
 17. An H, Liu X, Li Z, Zhang L, Zhang Y, Liu J, et al. Association of age at menarche with gestational hypertension and preeclampsia: a large prospective cohort in China. *J Clin Hypertens*. 2023;25(11):993–1000.
 18. Cheng X, Jiang Y, Chen X, Huang C, Li S. Early age at menarche is associated with an increased risk of preeclampsia and adverse neonatal outcomes: a 6-year retrospective study. *Arch Gynecol Obstet*. 2024;310(2):807–15.
 19. Ramesh K, Gandhi S, Rao V. Socio-demographic and other risk factors of preeclampsia at a tertiary care hospital, Karnataka: case control study. *J Clin Diagn Res*. 2014;8(9):JC01–4.
 20. Ayele AD, Tilahun ZA. Magnitude of preeclampsia and associated factors among women attending delivery service in Debre Tabor Specialized Hospital. *Ethiop J Health Sci*. 2022;32(2):279–88.
 21. Ayele AD, Tilahun ZA. Determinants of pre-eclampsia among women attending delivery services in public health institutions of Debre Tabor Town: a case–control study. *Reprod Health*. 2022;19(1).
 22. Petry CJ, Ong KK, Hughes IA, Acerini CL, Dunger DB. Age at menarche and blood pressure in pregnancy. *Pregnancy Hypertens*. 2019;15:134–40.
 23. Spradley FT, Palei AC, Granger JP. Increased risk for the development of preeclampsia in obese pregnancies: weighing in on the mechanisms. *Am J Physiol Regul Integr Comp Physiol*. 2015;309:R1326–43.
 24. Stöckl D, Meisinger C, Peters A, Thorand B, Huth C, Heier M, et al. Age at menarche and its association with the metabolic syndrome and its components: results from the KORA F4 study. *PLoS One*. 2011;6(10):e26076.