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Blood Pressure and Kidney Function in Preeclampsia: a Scoping Review

Reagen Jimmy Mandias*, Lea Andy Shintya

Faculty of Nursing, Universitas Klabat, Airmadidi, North Minahasa 95371, Indonesia
**Corresponding E-mail: rmandias@unklab.ac.id*

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Abstract
Preeclampsia is a serious pregnancy complication characterized by hypertension and impaired renal function. Understanding the relationship between maternal blood pressure and kidney function is essential for effective management to reduce adverse maternal and neonatal outcomes. This scoping review aimed to map the current evidence on the interaction between blood pressure and renal function in preeclampsia, including studied variables, methodologies, and research gaps. The review followed the Arksey and O'Malley framework and PRISMA-ScR guidelines, with a comprehensive search of MEDLINE, CINAHL, ERIC, and ScienceDirect databases. A total of 23 studies met the inclusion criteria, with most conducted in Asia, particularly China, and Latin America, especially Brazil. Seven major variable categories were identified: blood pressure, renal function, early pregnancy biomarkers, circulating biomarkers, inflammatory markers, molecular markers, and postpartum outcomes. The findings indicate a strong association between hypertension and renal dysfunction driven by placental insufficiency, angiogenic imbalance, and immune activation. Approximately 20.3% of women experienced persistent hypertension and 33.1% had ongoing proteinuria up to six months postpartum. In conclusion, preeclampsia involves complex pathophysiological mechanisms with potential long-term effects, highlighting the need for further research to elucidate molecular pathways and develop preventive strategies.

Keywords: *biomarkers, blood pressure, kidney function, preeclampsia*

Abstrak
Preeklampsia merupakan komplikasi kehamilan serius yang ditandai oleh hipertensi dan gangguan fungsi ginjal. Pemahaman hubungan keduanya penting untuk pengelolaan yang efektif guna menurunkan risiko pada ibu dan bayi. Tinjauan cakupan ini bertujuan memetakan penelitian terkait interaksi tekanan darah dan fungsi ginjal pada preeklampsia, termasuk variabel, metode, dan kesenjangan penelitian. Studi dilakukan menggunakan kerangka Arksey dan O'Malley serta pedoman PRISMA-ScR, dengan pencarian pada basis data MEDLINE, CINAHL, ERIC, dan *ScienceDirect*. Sebanyak 23 studi memenuhi kriteria, mayoritas berasal dari Asia (terutama Tiongkok) dan Amerika Latin (Brasil). Tujuh kelompok variabel diidentifikasi, meliputi tekanan darah, fungsi ginjal, biomarker kehamilan dini, biomarker sirkulasi, penanda inflamasi, penanda molekuler, dan luaran pascapersalinan. Hasil menunjukkan hubungan erat antara hipertensi dan gangguan ginjal yang dipengaruhi insufisiensi plasenta, disregulasi angiogenesis, dan aktivasi imun. Sekitar 20,3% wanita mengalami hipertensi persisten dan 33,1% proteinuria hingga enam bulan pascapersalinan. Disimpulkan bahwa preeklampsia melibatkan mekanisme kompleks dengan dampak jangka panjang, sehingga diperlukan penelitian lanjutan untuk memahami mekanisme molekuler dan mengembangkan strategi pencegahan.

Kata Kunci: biomarker, fungsi ginjal, preeklampsia, tekanan darah

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Introduction

Preeclampsia is recognized as a significant global maternal health concern, characterized by the onset of hypertension and proteinuria or other signs of end-organ dysfunction after 20 weeks of gestation (Yin et al., 2025a). The association between elevated blood pressure and impaired renal function has been extensively investigated, as renal dysfunction represents a key indicator of end-organ damage in individuals with preeclampsia.

Blood pressure measurement serves as a fundamental research parameter across the included studies. Hypertension is commonly defined using established criteria, namely systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg, confirmed on at least two occasions four hours apart after 20 weeks of gestation (Yin et al., 2025a). The severity of blood pressure elevation is frequently monitored as a continuous variable during pregnancy and the postpartum period, with some studies specifically assessing mean arterial pressure (Chen et al., 2025). In addition, several studies have explored the relationships among blood pressure metrics, including the interaction between systolic and diastolic values in individuals with preeclampsia (Y. Liu et al., 2024).

Renal function assessment involves multiple laboratory parameters serving as primary and secondary outcomes. Serum creatinine is widely regarded as a fundamental indicator of renal function, while various equations are used to estimate the glomerular filtration rate (eGFR) (Girsberger, 2018; Yin et al., 2025a). Proteinuria is evaluated through 24-hour urine collection, urine protein-to-creatinine ratio, and dipstick testing. Blood urea nitrogen (BUN) and uric acid levels are also considered additional indicators of renal function, with elevated uric acid levels being examined as potential clinical markers and predictors of preeclampsia severity (Chen et al., 2025; Y. Liu et al., 2024). Recent studies have highlighted the relevance of the cystatin C–based eGFR/creatinine-based eGFR ratio as a correlate of maternal morbidity in hypertensive disorders of pregnancy, as well as the role of urinary sediment in detecting cellular changes. Furthermore, gestational age at sampling has been identified as an important factor influencing the interpretation of creatinine levels (Girsberger, 2018; Liu et al., 2024; Yin et al., 2025a).

The reviewed studies also focused on the occurrence and severity of maternal end-organ dysfunction. Delivery timing, categorized as early (<34 weeks), late (≥34 weeks), and term delivery, is considered a critical outcome influenced by factors such as blood pressure and renal function status (X. Pan et al., 2025a). Fetal and neonatal outcomes, including gestational age at birth, birth weight, and neonatal complications, have also been examined in relation to the severity of maternal hypertension and renal impairment. Persistent postpartum hypertension and proteinuria are regarded as indicators of short-term maternal morbidity. Moreover, long-term outcomes, such as the development of chronic kidney disease over extended follow-up periods, have been investigated as broader outcome measures (Bianchi et al., 2025; Damm et al., 2024; Lee et al., 2017).

This scoping review aims to systematically map the existing evidence on blood pressure and renal function in preeclampsia. It seeks to identify the extent of research, variables examined, participant characteristics, methodologies employed, existing limitations, research gaps, and potential directions for future studies.

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Methods

A scoping review was conducted using the methodological framework by Arksy and O'Malley (2005). A literature search was conducted using the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (Tricco et al., 2018).

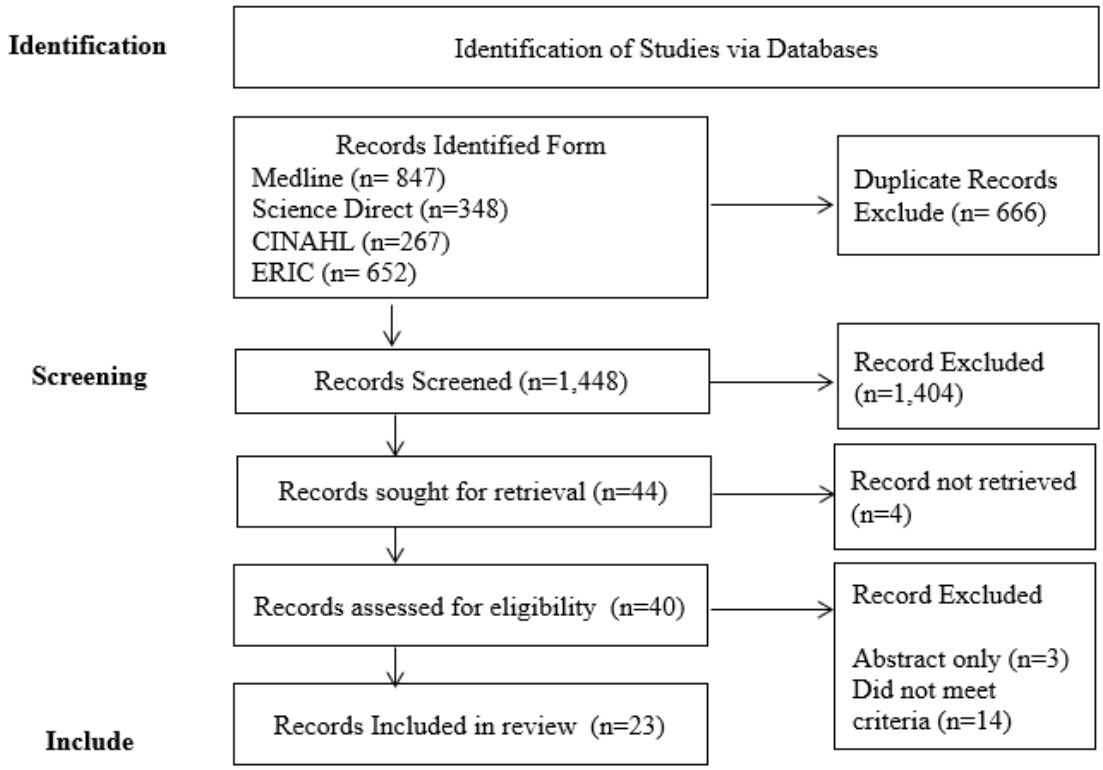

Figure 1. PRISMA Diagram

Articles that examined blood pressure and kidney function in preeclampsia were searched in MEDLINE, CINAHL, ERIC and Science Direct. A search strategy was developed using the main keywords "blood pressure", "kidney function", and "preeclampsia" to capture all available records that included the concept of blood pressure and kidney function in preeclampsia. The keywords were separated using Boolean terms AND and OR the search for keywords encompassed the terms derived from the Medical Subject Headings (MeSH) to ensure a comprehensive and targeted approach towards the attainment of the study objectives. Studies Research conducted in areas where patients with preeclampsia were present was included. The articles published in English and non-English with translations were included in the review. Unpublished abstracts from conference proceedings were excluded from the search results.

A three-stage screening process was employed by the researchers. The three authors (RM and LS) independently reviewed and screened the titles, abstracts, and full text of the searched articles against the inclusion and exclusion criteria. Duplicates were removed before screening. In collating and summarizing the findings, the articles were analyzed and categorized according to the common themes of blood pressure and kidney function in preeclampsia. A data abstraction table was developed to extract data from the studies

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included in the review. The data were tabulated and subjected to quantitative content analysis.

The authors observed the ethical conduct of this study by citing the studies that were reviewed using the APA 7th edition guidelines. No human respondents were involved in this scoping review.

Results

This scoping review identified and synthesized 23 studies examining the association between maternal blood pressure and renal dysfunction in pregnant women with preeclampsia. The following results section describes the characteristics of the included studies, the distribution of investigated variables, and the key findings addressing the research questions.

A total of 23 studies meeting the inclusion criteria were published between 2016 and 2026, reflecting a decade of research on this topic. The geographical distribution indicates a predominance of studies conducted in Asia, with China representing the primary research setting (n=10, 43.5%), followed by Brazil (n=4, 17.4%). Other contributing countries included the United States, Sweden, India, Taiwan, Switzerland, Iran, Turkey, and the United Kingdom (each n=1, 4.3%). This distribution may reflect both the burden of preeclampsia in middle- to high-income countries and the level of research engagement in this field. Study population sizes varied considerably, ranging from highly selected procedural samples to large population-based cohorts.

Table 1. Summary of Blood pressure and Renal Function in Preeclampsia

Author (Year)	Country	Population	Study Type	Variable Category	Specific Variables	Main Findings
(Zou et al., 2025)	China	84,298 pregnancies (4th-24th week GA)	Prospective Cohort	Early Pregnancy Biomarkers, Blood Pressure	Serum Uric Acid, GH/PE/HDP status	UA ↑ in GH/PE/HDP women. Nonlinear associations with GA, particularly after mid-pregnancy
Chen et al. (2026)	China	210 women (47 healthy, 48 NPHC, 115 PE)	Cross-sectional	Circulating Biomarkers, Renal Function	Mean Arterial Pressure (MAP), Aβ1-42, P-tau181, Memory function	Preeclampsia in women is characterised by elevated mean arterial pressure and increased biomarkers that are associated with impaired kidney function. A strong correlation has been demonstrated ($r= 0.855$, $p < 0.001$).

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Author (Year)	Country	Population	Study Type	Variable Category	Specific Variables	Main Findings
Pan et al. (2025)	China	1,455 pregnant women with ↑ BP; 1,329 included	Prospective Cohort (Jan 2020-Dec 2023)	Circulating Biomarkers, Blood Pressure	sFlt-1/PlGF ratio, Early/Late-onset PE, GA	In pregnant women with high blood pressure, a study found that the ratio of two proteins (sFlt-1/PlGF) can predict early-onset preeclampsia with 95.5% accuracy.
Gao et al. (2026)	China	PE patients (non-severe & severe)	Cross-sectional	Inflammatory Markers, Blood Pressure	SIRI, WBC, Neutrophils, Lymphocytes, Monocytes, BP	Research on patients with preeclampsia shows that systemic inflammatory indices (a combination of white blood cell markers) can distinguish between mild and severe preeclampsia
Zhu et al. (2025)	China	78,016 pregnant women (singleton)	Retrospective Cohort	Early Pregnancy Biomarkers, Blood Pressure	Early-pregnancy BP categories, Triglycerides, PE risk	The combination of high blood pressure in early pregnancy and high triglyceride levels increases the risk of preeclampsia by up to 8.95 times.
Yin et al. (2025)	China	120 women (60 PE, 60 non-PE)	Case-control	Early Pregnancy Biomarkers	First-trimester CA125, PE development	↑ First-trimester levels associated with PE development. Early biomarker for PE risk stratification
Palei et al. (2024)	Brazil	Pregnant women with PE and gestational hypertension	Cross-sectional	Circulating Biomarkers, Blood Pressure	VEGFR-3, Systolic/Diastolic BP, Fasting glucose, Newborn weight/height	Lower VEGFR levels are negatively correlated with blood pressure but positively correlated with higher birth weight.
Damm et al. (2024)	Sweden	50 hypertensive women (26 PE/HELLP, 24 without)	Cross-sectional	Renal Function, Blood Pressure	eGFR (creatinine), eGFR (cystatin C), eGFR ratio, Delivery timing	Low eGFR_cystatin C/eGFR_creatinine ratio ↔ maternal morbidity. Cystatin C better marker than

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Author (Year)	Country	Population	Study Type	Variable Category	Specific Variables	Main Findings
						urate/creatinine for PE
Singh et al., (2022)	India	203 pregnant women with pregnancy-induced hypertension	Cross-sectional	Blood Pressure, Renal Function	Systolic/Diastolic BP, LFT, KFT, Proteinuria, Pedal edema	Mean SBP 160 mmHg, DBP 101 mmHg. Correlation: proteinuria ↔ pedal edema; fundus findings ↔ deranged LFT/KFT
Kua et al., (2024)	USA	Infants at 6 months born to PE/healthy mothers	Prospective follow-up	Inflammatory Markers, Blood Pressure (offspring)	Plasma cytokines (IL-8, Angiopoietin-2), BP, Vascular reactivity	PE infants: ↓ vascular reactivity ($p=0.0345$), ↑ IL-8 ($p=0.03$), ↑ Angiopoietin-2 ($p=0.04$). IL-8 ↔ lower vascular reactivity
Liu et al. (2024)	China	60 women (30 PE, 30 non-PE)	Case-control	Molecular Markers, Blood Pressure	RSPO3, β-catenin expression, Systolic/Diastolic BP, Outcomes	↓ RSPO3 & β-catenin in PE blood/cord blood/placenta ($p<0.05$). ↑ Adverse outcomes in PE. RSPO3 ↔ BP parameters
Wang et al. (2026)	Taiwan	94 women (73 control, 11 GH, 10 PE)	Prospective pilot study	Circulating Biomarkers, Blood Pressure	miR-210-3p, GH/PE status, Aspirin use, Birth weight, Apgar score	miR-210-3p different trajectories in control/GH/PE. Earlier delivery in PE (37.3 vs 39.0 wks). Lower birth weight in PE (2596 vs 3104g)
Kaihara et al., (2024)	Brazil	Women with GH & PE (with/without severe features)	Cross-sectional metabolomic study	Metabolomic Variables, Blood Pressure	Circulating metabolites, Creatinine, Clinical chemistry	Distinct metabolomic profiles in HP/GH/PE-/PE+. Metabolite alterations correlate with disease severity and renal involvement
Viana-Mattioli et al. (2025)	Brazil	24 women (8 HP, 8 GH, 8 PE)	In vitro endothelial	Blood Pressure,	Systolic/Diastolic BP, Kidney function, Renal	GH/PE: ↑ SBP (120-131 mmHg) & DBP (79-87 mmHg) vs

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Author (Year)	Country	Population	Study Type	Variable Category	Specific Variables	Main Findings
			dysfunction study	Maternal Outcomes	markers, Placental weight	HP. PE: ↓newborn/placental weights.
Behboudi-Gandevani et al., (2020a)	Iran	1,851 women (177 prior PE, 1,674 non-PE); median FU 7.78 yrs	Prospective population-based cohort	Postpartum Outcomes, Renal Function	CKD development, BP, Long-term kidney function	CKD incidence: 35/100,000 (PE) vs 36/100,000 (non-PE), p=0.90. No significant ↑ CKD risk in PE group. Controversial finding
Guo et al., (2025)	China	GWAS participants (Mendelian randomization)	Bidirectional two-sample Mendelian randomization	Metabolomic Variables, Blood Pressure	Circulating metabolites (genetic), GH/PE/Eclampsia	Causal relationships identified between metabolites and hypertensive disorders. Metabolite-specific effects demonstrate metabolic derangement
Pan et al. (2020)	China	Severe PE patients	Cross-sectional	Molecular Markers, Blood Pressure	Urotensin II, Pyroptosis markers (Caspase-1, NLRP3, GSDMD), 24h-urinary protein	patients with severe preeclampsia, levels of urotensin II (a potent vasoconstrictor peptide) are elevated and strongly correlated with blood pressure (r = 0.916) and urinary protein (r = 0.73).
Irge et al., (2016)	Turkey	Placentae from normal & preeclamptic pregnancies		Molecular Markers	5-HT7 receptor expression in placenta, BP status (≥140/90)	↑ 5-HT7 receptor expression in PE placentae. New step in PE pathophysiological cascade. Different expression patterns vs control
Wilkerson & Ogunbodede, (2019)	USA	Review of hypertensive disorders of pregnancy		Blood Pressure Classification	Chronic HTN, Gestational HTN, PE-Eclampsia, Chronic HTN with superimposed PE	Four categories hypertensive disorders in pregnancy. Leading causes maternal/fetal morbidity & mortality. Proper

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Author (Year)	Country	Population	Study Type	Variable Category	Specific Variables	Main Findings
						diagnosis crucial for treatment
Liu et al. (2020)	China	Severe PE patients (early delivery vs continuation)		Renal Function, Blood Pressure	Serum uric acid, Liver enzymes (ALT, AST), Kidney function (Cr, BUN)	Serum uric acid has role in management decision (immediate delivery vs prolongation). Uric acid biomarker for clinical guidance in severe PE
Kurlak et al., (2023)	UK	Pregnant women (normotensi ve, early/late-onset PE)		Renal Function	Antioxidant micronutrients (copper, zinc), Placental tissue, Urine, Fetal circulation	Early- and late-onset preeclampsia indicate that levels of antioxidant minerals (copper and zinc) in urine are elevated in preeclampsia.

Blood Pressure

Blood pressure was examined in 15 studies (65%), highlighting its role as a fundamental parameter in investigating the relationship between blood pressure and renal dysfunction. These studies assessed systolic and diastolic blood pressure as diagnostic markers and indicators of preeclampsia severity. Mean arterial pressure (MAP) was evaluated in several studies as a more comprehensive measure of hemodynamic burden on the vascular system and target organs (Guo et al., 2025; Kaihara et al., 2024; Singh et al., 2022; Wilkerson & Ogunbodede, 2019; Zou et al., 2025). The use of blood pressure categories (normal, elevated, stage 1, stage 2) for risk stratification was commonly reported. Large-scale studies consistently demonstrated higher systolic and diastolic blood pressure levels in patients with pregnancy-induced hypertension (PIH) compared with healthy pregnant women. Furthermore, MAP values differed significantly across control, gestational hypertension, and preeclampsia groups (Damm et al., 2024; D. Liu et al., 2020; Y. Liu et al., 2024; Palei et al., 2025; X. Pan et al., 2025; Viana-Mattioli et al., 2025).

Renal Function

Renal function was investigated in 7 studies (30%), employing a wide range of parameters reflecting glomerular filtration, excretory function, and tubular injury. Serum creatinine, a metabolic byproduct of creatine phosphate primarily excreted by the kidneys, was commonly used as a baseline indicator of filtration function. Renal function-related markers, including creatinine and blood urea nitrogen (BUN), were consistently reported to be elevated in preeclampsia groups compared with controls (Damm et al., 2024; Gao et al., 2026; Girsberger et al., 2018a, 2018b; Kurlak et al., 2023; D. Liu et al., 2020; X. Pan et al., 2025b). Uric acid has also emerged as an important biomarker in preeclampsia due to its association with underlying renal dysfunction. In addition, proteinuria was identified as a

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key clinical manifestation, with significantly higher levels observed in affected individuals (Palei et al., 2025).

Early Pregnancy Biomarkers

Biomarkers detectable during mid-pregnancy were investigated in several studies, primarily to identify women at high risk of developing preeclampsia and other hypertensive disorders. Triglycerides, as indicators of lipid metabolism, were identified as early predictors of preeclampsia risk (Yin et al., 2025). Studies examining the association between early pregnancy triglyceride levels, blood pressure, and preeclampsia risk demonstrated a consistent increase in risk corresponding to higher triglyceride concentrations and elevated blood pressure (Chen et al., 2025; Palei et al., 2025; Zhu et al., 2025; Zou et al., 2025).

Circulating Biomarkers

Circulating biomarkers reflecting angiogenic and endothelial dysfunction were assessed in several studies. The ratio of soluble fms-like tyrosine kinase-1 (sFlt-1), an anti-angiogenic factor, to placental growth factor (PlGF), a pro-angiogenic factor, was identified as a reliable indicator of angiogenic imbalance in preeclampsia, with varying diagnostic thresholds (X. Pan et al., 2025).

Inflammatory Markers

Preeclampsia is characterized by a pronounced systemic inflammatory response, which has been evaluated using composite inflammatory indices and individual cell counts. The systemic inflammatory response index (SIRI), which integrates white blood cell differential counts, was associated with renal function-related parameters, suggesting an interaction between inflammation and renal dysfunction in preeclampsia (Gao et al., 2026).

Molecular Markers

Several studies have identified molecular mediators that may contribute directly to elevated blood pressure and renal injury. Urotensin II (UII), a potent vasoconstrictive peptide, demonstrated increased expression in severe preeclampsia and showed strong correlations with blood pressure parameters and proteinuria (Irge et al., 2016; Y. Liu et al., 2024; X. Pan et al., 2025).

Postpartum Outcomes

Postpartum follow-up studies provide insights into the long-term consequences of preeclampsia-associated hypertension and renal dysfunction. In cohorts with a mean follow-up of 172 days postpartum, persistent hypertension (blood pressure ≥140/90 mmHg or use of antihypertensive medication) was observed in 20.3% of women, with some requiring ongoing pharmacological treatment (Girsberger et al., 2018). Persistent proteinuria was also common, affecting 33.1% of women at this time point. While some abnormalities may resolve following recovery from pregnancy, a subset of women continues to exhibit persistent renal and cardiovascular alterations (Behboudi-Gandevani et al., 2020b; Viana-Mattioli et al., 2025).

Discussions

The association between maternal hypertension and renal dysfunction in preeclampsia is not coincidental but reflects interconnected underlying pathophysiological mechanisms. Elevated blood pressure and renal injury are driven by shared early processes, including

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placental insufficiency, angiogenic imbalance, and immune activation. These mechanisms may act synergistically to increase blood pressure while simultaneously impairing renal function (Viana-Mattioli et al., 2025).

Increased blood pressure may further contribute as an active hemodynamic factor that sustains and exacerbates renal injury (Sun et al., 2020). This interaction potentially creates a self-perpetuating pathological cycle, in which hypertension induces endothelial injury, leading to systemic vascular dysfunction that, in turn, further elevates blood pressure (Qasim et al., 2025).

The relationship between hypertension and renal impairment can be quantitatively assessed through specific blood and urinary biomarkers. Higher blood pressure levels are generally associated with greater renal dysfunction, as reflected by increased serum creatinine, reduced estimated glomerular filtration rate (eGFR), elevated uric acid levels, and the presence of proteinuria (Vaidya & Aeddula, 2024). Importantly, early pregnancy biomarkers may help identify individuals at increased risk, suggesting a shared etiological pathway between hypertension and renal dysfunction (Ng et al., 2024).

The timing of preeclampsia onset also appears to influence the severity of renal impairment, with early-onset disease typically associated with more pronounced renal dysfunction (Auger et al., 2025). Although delivery remains the definitive management for acute preeclampsia, normalization of blood pressure and renal function is not consistently achieved in all cases. Persistent postpartum abnormalities observed in some individuals suggest that preeclampsia may result in residual renal and vascular alterations, potentially contributing to long-term kidney disease, although current evidence remains inconclusive (Srialluri et al., 2023).

Conclusions

This scoping review synthesized evidence from 23 studies (2016–2026) examining the relationship between maternal blood pressure and renal dysfunction in preeclampsia. The findings indicate that research has been predominantly conducted in Asia, particularly in China (43.5%), followed by Brazil (17.4%), reflecting both disease burden and research activity in middle-income settings.

Hypertension and renal dysfunction appear to represent integrated manifestations of shared pathophysiological mechanisms, including placental insufficiency, angiogenic imbalance (elevated sFlt-1 and reduced PlGF), and immune activation. These processes collectively contribute to endothelial dysfunction, resulting in concurrent increases in blood pressure and renal injury.

Several research gaps were identified, including limited understanding of specific molecular mechanisms, a lack of long-term longitudinal studies, insufficient validation of biomarker-based interventions, variability in methodological approaches, and underrepresentation of low- and middle-income countries. Future research should prioritize clinical trials to validate biomarkers, in-depth mechanistic investigations, standardization of research protocols, long-term cardio-renal outcome studies, and broader inclusion of diverse populations.

Overall, preeclampsia involves a complex interplay between placental dysfunction, angiogenic imbalance, and endothelial injury, leading to concurrent hypertension and renal damage. Emerging biological evidence suggests substantial potential for early risk

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identification and prevention; however, a deeper understanding of the underlying mechanisms is essential to optimize clinical strategies and reduce maternal morbidity.

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