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Incidence of pregnancy-related acute kidney injury and associated perinatal and obstetric risk factors; a 5-year updated systematic review analysis from 2022 to 2026

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ABSTRACT

Introduction: Pregnancy-related acute kidney injury (PR-AKI) is a serious but potentially preventable complication that contributes to maternal and perinatal morbidity and mortality, particularly in low- and middle-income settings. Marked variation in reported incidence and underlying causes across regions suggests important differences in obstetric care and health-system performance. This systematic review study aimed to synthesize contemporary evidence on the incidence of PR-AKI and to identify the major obstetric and perinatal risk factors associated with its occurrence between 2022 and 2026.

Methods and Materials: This systematic review included observational studies (cohort, case–control, and cross-sectional designs) reporting PR-AKI between 2022 and 2026 that were identified through a multi-database search supplemented by hand-searching reference lists. Data on study characteristics, PR-AKI incidence, and obstetric and perinatal risk factors were extracted in duplicate using a standardized form, and risk of bias was appraised with the Newcastle–Ottawa Scale. Given methodological and clinical heterogeneity, findings were synthesized narratively, with incidence estimates and major risk constellations summarized in tables.

Results: Across 17 studies comprising 3,375 women, the reported incidence of PR-AKI showed marked heterogeneity, ranging from low rates in population-based cohorts in high-income countries to very high rates among high-risk obstetric populations and tertiary referral centres in low- and middle-income settings. Hypertensive disorders of pregnancy, particularly pre-eclampsia and eclampsia, together with sepsis and obstetric haemorrhage consistently emerged as the leading, and frequently overlapping, etiologic factors for PR-AKI.

Conclusion: The PR-AKI remains a major yet largely preventable obstetric complication, with incidence varying markedly across health-care settings and strongest contributions from hypertensive disorders, sepsis, and obstetric haemorrhage. These results highlight an urgent need for health-system–level interventions that emphasize early identification and tight control of hypertensive disease in pregnancy, alongside universal access to skilled intrapartum care with effective prevention and management of bleeding and infection.

Registration: This study has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO (ID: CRD420261394310) and the Research Registry (UIN: reviewregistry2104) websites.

Review

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Implication for health policy/practice/research/medical education:
Pregnancy-related acute kidney injury (PR-AKI) emerges from this systematic review study as a major yet largely preventable obstetric complication, with incidence varying widely across health-care settings but consistently driven by hypertensive disorders of pregnancy, sepsis, and obstetric hemorrhage, which often coexist. Together, these findings position PR-AKI as a sensitive indicator of maternal health-system performance and highlight the need to strengthen antenatal detection and control of hypertensive disease, while simultaneously ensuring universal access to skilled intrapartum care that can provide prompt, effective management of bleeding and infection.

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Introduction

Pregnancy is accompanied by profound physiological adaptations that substantially alter renal structure and function (1). As early as the first trimester, systemic vasodilation driven by hormonal changes leads to increased renal blood flow and a dramatic rise in glomerular filtration rate (GFR), which increases by up to 40–50% compared with non-pregnant values (1,2). A systematic review and meta-analysis of 29 studies confirmed that inulin clearance in uncomplicated pregnancy peaks at 36–41 weeks, with a 55.6% increase over the non-pregnant baseline, and that serum creatinine decreases by approximately 23% at 15–21 weeks of gestation (2). These physiological alterations modify standard reference values and can complicate the accurate diagnosis of renal dysfunction during gestation (3). Additionally, tubular function is altered, resulting in mild proteinuria, glucosuria, and modifications in electrolyte and acid-base handling, all of which must be considered when evaluating kidney status in the pregnant patient (1).

Acute kidney injury (AKI) is defined as a rapid decline in kidney function, characterized by an abrupt rise in serum creatinine of ≥0.3 mg/dL within 48 hours, or a ≥50% increase from baseline within seven days, or a reduction in urine output to less than 0.5 mL/kg/hour for more than six hours, as specified by the Kidney Disease: Improving Global Outcomes (KDIGO) criteria (4). In the context of pregnancy, AKI—referred to as pregnancy-related AKI (PR-AKI)—encompasses renal dysfunction occurring during gestation, labour, and the postpartum period (5,6). The diagnostic application of KDIGO criteria in pregnancy is complicated by the physiological reduction in serum creatinine, which may lead to under-recognition of renal injury if non-pregnant thresholds are applied (5). Key obstetric precipitants include preeclampsia, eclampsia, HELLP (haemolysis, elevated liver enzymes, and low platelet count) syndrome, puerperal sepsis, postpartum haemorrhage, and acute fatty liver of pregnancy (7). Preeclampsia and the hypertensive disorders of pregnancy are major contributors to maternal morbidity and mortality worldwide, and preeclampsia commonly leads to AKI through endothelial dysfunction, impaired placentation, and imbalanced angiogenic signaling (8).

The global epidemiology of PR-AKI is characterised by marked geographical disparity, with substantially higher incidence and case fatality in low- and middle-income countries (LMICs) (9). A comprehensive systematic review and meta-analysis in 2022, encompassing 31 studies and 57,529,841 participants, reported a pooled PR-AKI incidence of 2.0% (95% CI: 1.0–3.7%), with preeclampsia identified as the most common cause in 36.6% of cases, and a pooled maternal mortality rate of 12.7% (10). A recent meta-analysis published in the bulletin of the World Health Organization (WHO), which included 40 studies covering 424,081 pregnancies across 15 LMICs, reported a pooled incidence of 91 cases per 10,000 pregnancies (95% CI: 63–133), with the highest rates observed in the WHO African region (254 per 10,000; 95% CI: 152–421), a case fatality rate of 10.8%, and neonatal death or stillbirth in 29.8% of cases (9). A 2025 consensus report from the 32nd Acute Disease Quality Initiative (ADQI) workgroup confirmed that PRAKI is associated with a 13-fold increase in the odds of maternal mortality, a 9-fold increase in the odds of cardiovascular events, and a 30–60% increase in the risk of fetal mortality and morbidity (11). Identified obstetric risk factors include hypertensive disorders of pregnancy, obstetric haemorrhage, sepsis, multiparity, and absence of antenatal care, while adverse perinatal outcomes encompass preterm birth, low birth weight, and increased perinatal mortality (7). A prospective multicentre Nigerian cohort study reported that PR-AKI was associated with significantly increased odds of perinatal mortality (adjusted OR = 2.23; 95% CI: 1.17–4.23) (12). Given the persistent global burden and the complex interplay of obstetric and perinatal risk factors, updated systematic evidence is required to guide preventive strategies and clinical management.

Objectives

The primary objective of this study is to provide an updated, comprehensive synthesis of contemporary evidence published between 2022 and 2026 on PR-AKI. Specifically, the review sought to quantify the incidence of PR-AKI across a spectrum of health-care settings to characterize the extent of geographical and health-system variation. A further objective was to systematically delineate the principal obstetric and perinatal determinants of PR-AKI

and to evaluate how these risk factors cluster and overlap in different clinical contexts. Through this approach, the study aimed to generate a robust evidence base to inform targeted preventive strategies, guide clinical risk stratification, and highlight priorities for future research and health-system strengthening in maternal kidney health.

Methods and Materials

Study design

This study was designed and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (13) for systematic reviews. It followed a predefined protocol specifying the research question, eligibility criteria, data sources, and analytic approach, and adhered to the four standard PRISMA phases (identification, screening, eligibility, and inclusion). A comprehensive, multi-database search was undertaken over a defined time window (2022–2026), with transparent documentation of search terms, limits, and dates. The synthesis primarily used a narrative approach, structured around incidence estimates and major obstetric and perinatal risk factors for PR-AKI, and results were summarized in text, tables, and a PRISMA flow diagram to ensure transparent reporting of the study selection process.

Search strategy

The search strategy was developed in consultation with an experienced medical librarian and structured around the PICO framework, targeting three main concepts: pregnancy, acute kidney injury, and epidemiologic/risk-factor terms. We systematically searched MEDLINE (via PubMed), Embase, Scopus, Web of Science, Cochrane Library, and Google Scholar search engine from 1 January 2022 to 30 January 2026, without geographic restrictions and limited to human studies published in English. The core PubMed search combined controlled vocabulary (MeSH/Emtree) and free-text terms, for example: ("Pregnancy"[Mesh] OR pregnancy OR pregnant OR obstetric OR peripartum OR postpartum) AND ("Acute Kidney Injury"[Mesh] OR "Acute Renal Failure"[Mesh] OR acute kidney injury OR acute renal failure OR PR-AKI OR "pregnancy-related acute kidney injury" OR "pregnancy-associated acute kidney injury") AND (incidence OR epidemiolog OR prevalence OR "risk factor" OR determinant OR outcome).

Database-specific adaptations of this strategy used equivalent subject headings and syntax in Embase, Scopus, Web of Science, Cochrane Library, and Google Scholar search engine. Reference lists of all included articles and relevant reviews were manually screened to identify additional eligible studies not captured by the electronic search. Search results were exported to a reference manager, where duplicates were removed before screening.

PICO Component

- Population (P): Pregnant and postpartum women (up to 6–12 weeks after delivery) in any clinical setting (community, hospital, or intensive care) who were diagnosed with PR-AKI.
- Exposure/Intervention (I): Obstetric and perinatal conditions potentially associated with PR-AKI.
- Comparison (C): No comparison
- Outcomes (O): Primary outcome was the incidence or frequency of PR-AKI. Secondary outcomes included the identification of AKI-related risk factors.

Eligibility criteria

Studies were eligible if they: (1) included pregnant or postpartum women (up to 6–12 weeks after delivery); (2) reported primary data on PR-AKI, defined by an established valid guideline or a clearly described study-specific definition; and (3) provided at least one quantitative measure of PR-AKI frequency (incidence, proportion of a defined obstetric or AKI cohort, or number of PR-AKI cases) and/or examined obstetric or perinatal risk factors. Eligible designs were observational cohort, case-control, or cross-sectional studies conducted in any clinical setting (community, hospital, or intensive care), provided they were published between January 2022 and January 2026 in peer-reviewed journals and available in full text in English. Exclusion criteria comprised: narrative reviews, systematic reviews, editorials, conference abstracts without full papers, single-case reports, and case series; studies in which AKI was not clearly linked to pregnancy or the postpartum period; reports that lacked sufficient information to derive either an incidence measure or an identifiable set of PR-AKI risk factors; and papers published before 2022, as well as low-quality studies.

Quality assessment

Quality assessment was performed independently by two reviewers using the Newcastle–Ottawa Scale (NOS) adapted for observational cohort and case–control designs, with studies rated on a nine-star system. Within the selection domain (maximum four stars), we evaluated the representativeness of the study cohort, the adequacy of exposure ascertainment, and whether the absence of AKI at baseline was clearly demonstrated when relevant. For comparability (maximum two stars), we awarded stars when studies controlled, either by design or analysis, for key confounders, and an additional star when further important variables were considered. In the outcome domain (maximum three stars), we assessed the objectivity and validity of PR-AKI outcome definitions, the method and timing of outcome ascertainment (including follow-up for renal recovery or chronic kidney disease), and the adequacy and completeness of follow-up. Each study therefore received a total score between 0 and

9 stars and was categorized as follows: high quality (7–9 stars), moderate quality (5–6 stars), or low quality (≤4 stars). Studies with fewer stars commonly had limitations in exposure or outcome ascertainment (e.g., unclear or non-standard AKI definitions), restricted adjustment for confounding, or incomplete follow-up. All included studies had moderate to high quality (14).

Data extraction

Data extraction was conducted by two independent reviewers using a standardized, pre-specified form that was developed a priori in accordance with the review objectives. Extracted data included first author and publication year, study design, country, total sample size (overall cohort or PR-AKI cases, as reported), mean or median age of women with AKI, the measure of PR-AKI incidence, study period, and the most commonly reported AKI-related obstetric and perinatal risk factors. Any discrepancies between reviewers were resolved by discussion, with recourse to a third reviewer when consensus could not be reached.

Results

The database search initially yielded 589 records, of which 374 were removed as duplicates before screening the titles and abstracts of 215 studies. After this screening step, 121 records were excluded, leaving 94 articles selected for retrieval. Of these, 49 could not be retrieved in full text, so 45 articles proceeded to full-text eligibility assessment. Twenty-eight studies were then excluded because they were reviews, case reports, or case series, reported outcomes outside the scope of this review, or were published before 2022. Ultimately, 17 studies met all inclusion criteria and were incorporated into the final qualitative synthesis (Figure 1).

Across the 17 included studies with 3,375 participants, PR-AKI was investigated mainly using prospective or retrospective observational designs, with one large population-based cohort, encompassing settings in both high- and low-resource countries. AKI incidence varied widely depending on the denominator and study design, ranging from 1.02–11.2 per 10,000 pregnancies in population-level cohorts in England and India to 7.6% of all pregnancies or 22.2–26.1% within high-risk obstetric cohorts in Nigeria and tertiary referral centers. The mean age of affected women was consistently in the mid-twenties to early thirties, reflecting the typical reproductive age group. Hypertensive disorders of pregnancy (especially pre-eclampsia and eclampsia) and sepsis emerged as the dominant etiologies in almost all series, often acting in

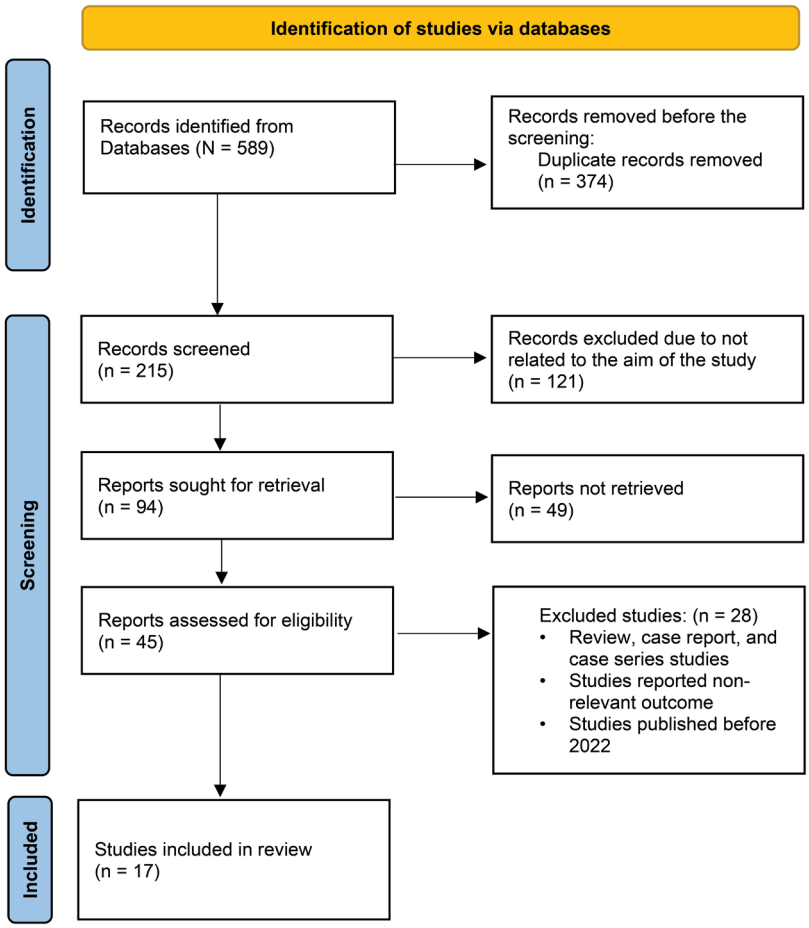

Figure 1. The PRISMA flowchart of the study selection.

combination and frequently accompanied by obstetric haemorrhage, including antepartum and postpartum haemorrhage. Additional contributors such as HELLP syndrome, thrombotic microangiopathy, hemorrhagic shock, and post-abortion complications were variably reported, while a smaller subset of studies from South Asia and Africa highlighted the high burden of anaemia, poor antenatal care, and late presentation in shaping both AKI risk and adverse outcomes. Collectively, these data indicate that PR-AKI in contemporary practice remains concentrated in late pregnancy and the postpartum period, is driven predominantly by preventable complications of hypertensive disease, sepsis, and haemorrhage, and shows substantial heterogeneity in incidence and case mix across regions and health-system contexts (Table 1).

Discusion

The present systematic review demonstrated marked heterogeneity in reported incidence across settings, with hypertensive disorders of pregnancy, particularly preeclampsia and eclampsia, sepsis, and obstetric haemorrhage consistently identified as the leading etiologic factors. These findings are broadly consistent with the cumulative body of evidence and reinforce the view that PR-AKI remains a major, yet largely preventable, obstetric complication worldwide (11,12). The substantial variation in incidence observed across the included studies mirrors the pattern reported in prior systematic reviews (9,10). Population-based cohorts from high-income countries have historically reported lower rates, whereas studies drawn from tertiary referral centres or high-risk obstetric populations in LMICs have documented markedly higher rates (9). A meta-analysis by Trakarnvanich et al reported a pooled PR-AKI incidence of 2.0% (95% CI: 1.0–3.7%) across 31 studies and over 57 million participants, underscoring the wide span of estimates attributable to differences in case-mix, diagnostic criteria, and healthcare-system capacity (10). More recently, a WHO Bulletin meta-analysis covering 424,081 pregnancies in 15 LMICs reported a pooled incidence of 91 per 10,000 pregnancies, rising to 254 per 10,000 in the WHO African region, a finding consistent with the gradient between resource-rich and resource-limited settings identified in the present review (9). Similarly, a 2026 systematic review and meta-analysis by Pota et al, focusing specifically on obstetric intensive care unit admissions, reported a global pooled incidence of maternal AKI of 2,813 per 10,000 obstetric ICU admissions, further reflecting the markedly elevated burden among critically ill subpopulations (30). This gradient likely reflects differences in access to antenatal care, early recognition of obstetric complications, and availability of critical care facilities, rather than intrinsic differences in disease biology.

The predominance of hypertensive disorders of pregnancy, particularly preeclampsia and eclampsia, as etiologic drivers identified in the present review is congruent with multiple independent published reports (7,31). Conti-Ramsden et al demonstrated that AKI complicated approximately 15.3% of preeclampsia admissions in a multicentre South African cohort, with over half of cases classified as stage 2 or 3, and with significantly higher rates of maternal death, stillbirth, and perinatal mortality among affected women (31). Sandilya et al similarly identified preeclampsia as the most common antecedent of PR-AKI, closely followed by puerperal sepsis and postpartum hemorrhage, consistent with the etiologic constellation identified across the studies synthesized in the present review (7). The co-occurrence and frequent overlap of these risk factors, where sepsis may complicate uncontrolled hypertensive disease or follow obstetric haemorrhage, represents an important clinical challenge that has been highlighted across the contemporary literature (21,32). In this respect, the recent consensus report of the 32nd ADQI workgroup noted that PR-AKI is associated with a 13-fold increase in the odds of maternal mortality and a 9-fold increase in the odds of cardiovascular events, emphasizing the catastrophic potential of these compounding risk factors when left unaddressed (11).

The findings of this review carry important clinical and policy implications. The identification of hypertensive disorders, sepsis, and obstetric hemorrhage as consistently predominant, and largely preventable, causes of PR-AKI underscores the potential for targeted health-system interventions to reduce the burden of this condition (9,11). A systematic review of PR-AKI causes and perinatal outcomes published in 2025 concluded that obstetric hemorrhage, sepsis, and eclampsia are both avoidable and manageable, and that effective antenatal care and skilled intrapartum care are critical to prevention (32). Universal access to antenatal surveillance, enabling early detection and control of hypertensive disease, combined with the capacity to manage intrapartum hemorrhage and infection, represents the cornerstone of any prevention strategy, particularly in LMIC settings where the burden is disproportionately concentrated (9,32).

In summary, the present 5-year updated systematic review demonstrates that PR-AKI remains a major and incompletely prevented obstetric complication, with incidence varying substantially across healthcare settings and the greatest burden borne by women in low- and middle-income countries. Hypertensive disorders of pregnancy, sepsis, and obstetric hemorrhage, frequently overlapping, are the principal and modifiable contributors to PR-AKI. These findings reinforce an urgent need for health-system–level strategies that prioritize early identification and treatment of hypertensive disease in pregnancy, universal skilled intrapartum care, and effective management of haemorrhage and infection, with particular emphasis on strengthening obstetric services in resource-limited settings.

Table 1. Baseline characteristics of included studies

Authors	Publication year	Study design	Country	Sample size	Mean age of AKI patients (year ± SD) / Median (IQR)	AKI incidence	Study period	Most common AKI-related risk factors
Leal et al (15)	2025	Cohort	England	138	29.9 ± 5.9	AKI rose from 2.9 to 11.2 per 10,000 pregnancies (1998–2002 vs 2013–2017)	Apr 1, 1998 to Feb 17, 2017	Hypertensive disorders, postpartum hemorrhage, sepsis
Waziri et al (12)	2024	Prospective observational	Nigeria	443	28 ± 6	26.1%	Sept 1, 2019 to Jul 31, 2022	Pre-eclampsia: 50.4% Hypertension: 12.4% Postpartum hemorrhage: 10.6% Eclampsia: 7.1% Antepartum hemorrhage: 6.2% Sepsis: 4.4% HELLP syndrome: 1.8%
Berhe et al (16)	2024	Retrospective observational	Ethiopia	187 women with PR-AKI	27 (17 - 50)	68 per 100,000 births	Jan 1, 2017, to Dec 31, 2021	Hypertensive disorders: 75.4% HELLP syndrome: 26.7 Sepsis: 49.2 Pre-renal AKI: 40.6
Sahay et al (17)	2022	Retrospective observational	India	395	27 ± 3	8.1%	A 10-year period	Preeclampsia: 44.5% Puerperal sepsis: 33.4% Haemorrhage: 19.2%
Suman et al (18)	2025	Prospective observational	India	43 Obstetric patients	28.67 ± 4.69	28.67 ± 4.69	Nov 2022 to Feb 2024	Sepsis: 74.4% Hemorrhage: 13.9%
Msilanga et al (19)	2025	Retrospective cohort	Tanzania	112	31.3 ± 6.2	NR	Jan 2022 to Dec 2024	Hypertensive disorders: 67% Obstetric hemorrhage: 17%
Mal et al (20)	2023	Prospective observational	Pakistan	60	28.67 ± 5.41	NR	16 Apr 2022 to 15 Oct 2022	Puerperal sepsis: 33.3% Postpartum hemorrhage: 26.7% Antepartum hemorrhage: 23.3% Combined hemorrhage and sepsis: 13.3%
Iqbal Anvar et al (21)	2023	Retrospective observational	India	70	24.56 ± 4.2	2.09 per 1,000 deliveries	May 2016 to Aug 2020	Sepsis: 74.33% Preeclampsia/eclampsia: 62.85% LSCS: 38.6% Abruptio placentae: 15.7% Postpartum hemorrhage: 15.7% Post-abortion: 11.4% HELLP syndrome: 10.46%

Table 1. Continued

Authors	Publication year	Study design	Country	Sample size	Mean age of AKI patients (year ± SD) / Median (IQR)	AKI incidence	Study period	Most common AKI-related risk factors
Choudhary et al (22)	2024	Prospective observational	India	62	25.08 ± 4.25	NR	Oct 2021 to Sept 2022	Puerperal sepsis: 29.0% Preeclampsia/eclampsia: 22.6% Hemorrhagic shock: 16.1%
Shahid et al (23)	2025	Retrospective observational	Pakistan	42	Age range 18–45 years	NR	Apr 2018 to Apr 2025	Postpartum hemorrhage: 35.7% Sepsis: 23.8%
Ankawi et al (24)	2025	Retrospective cohort	Saudi Arabia	129	NR	19.4%	Jan 2020 to Dec 2022	Pre-existing diabetes mellitus: OR 3.53 HELLP syndrome: OR 25.25 Intrauterine fetal death: OR 4.105
Sachan et al (25)	2022	Prospective	India	150	Majority 26–30 years old	1.02	Jun 2019 to Oct 2020	Hypertensive disorders: 48% Puerperal sepsis: 45% Hemorrhage (uterine/obstetric): 34%
Sandilya et al (7)	2023	Prospective observational	India	50	25.18 ± 3.8	NR	2021–2022	Preeclampsia: 28% Puerperal sepsis: 24% Postpartum hemorrhage: 20% Abruption: 14%
Yadav et al (26)	2022	Prospective observational	India	51	25.9 (range 20–40 years)	NR	1 Jul 2015 to 31 Aug 2016	Pre-eclampsia/eclampsia Antepartum hemorrhage Postpartum hemorrhage HELLP syndrome Sepsis
Orhewere et al (27)	2023	Prospective cohort	Nigeria	162	30.05 ± 1.28	22.2	10 Mar 2020 to 16 Apr 2020	Obstetric hemorrhage (66.7%), eclampsia (19.4%), sepsis (13.9%)
Ng'ethe et al (28)	2025	Retrospective descriptive	Kenya	203	28 (IQR 22–33)	NR	1 Feb 2020 – 1 Feb 2023	Hypertensive disorders: 64.1% Obstetric hemorrhage: 38.4% Sepsis: 36.5%
Yadla et al (29)	2025	Retrospective cohort	India	500	25 ± 4	7.6	2014–2024	Preeclampsia: 20.6% Sepsis: 25.8% Combination of preeclampsia and sepsis: 33.8%

AKI: Acute kidney injury, SD: Standard deviation, IQR: interquartile range, NR: Not reported, PR-AKI: Pregnancy-related acute kidney injury, HELLP: Hemolysis elevated liver enzymes and low platelets, LSCS: Lower segment cesarean section.

Conclusion

In conclusion, these findings confirm that PR-AKI remains an important, system-sensitive obstetric complication with highly heterogeneous incidence across settings, driven largely by preventable hypertensive disorders, sepsis, and obstetric haemorrhage. This underscores the need for health-system–level strategies that integrate robust antenatal detection and management of hypertensive disease, universal access to skilled intrapartum care with effective haemorrhage and infection control. A coordinated global research agenda using standardized case definitions, trimester-specific reporting, and evaluation of context-adapted preventive and therapeutic interventions, especially in low-resource environments, is essential to lessen the burden of PR-AKI and to improve both maternal renal prognosis and downstream cardiovascular and developmental outcomes for offspring.

Limitations of the study

First, the evidence base is dominated by observational studies from tertiary centres and high-risk obstetric populations, which may overestimate incidence and limit generalizability to community or primary-care settings. Second, there was substantial heterogeneity in PR-AKI definitions, staging criteria, and the time window used to attribute AKI to pregnancy, which complicates direct comparison of incidence estimates across studies. Third, important obstetric and perinatal risk factors were not uniformly measured or adjusted for, raising the possibility of residual confounding in reported associations. Fourth, language and time-window restrictions (English-language publications from 2022 onward) may have led to the omission of relevant studies, and publication bias cannot be excluded, particularly for smaller negative or null studies. Finally, the reliance on narrative synthesis, driven by methodological and clinical heterogeneity, precluded formal meta-analysis and limits the precision with which pooled incidence or effect estimates can be quantified.

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Authors' contribution

Conceptualization: Zahra Hamidi Madani and Zeinab Zamanpour.
Data curation: Sara Sadat Mirhosseini, Zeinab Zamanpour, and Zahra Kamranirad
Investigation: Zahra Hamidi Madani, Fatemeh Rostami, and Ladan Parsa.
Methodology: Mohammad Mehdi Darzi and Fatemeh Sharifian
Supervision: All authors.
Visualization: Narges Mostafaloo and Fatemeh Sharifian.
Writing–original draft: All authors.
Writing–review and editing: All authors.

Conflicts of interest

The authors declared no conflict of interest

Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process

During the preparation of this work, the authors utilized AI (Perplexity and Grammarly) to refine grammar points and language style in writing. Subsequently, the authors thoroughly reviewed and edited the content as necessary, assuming full responsibility for the accuracy and content of the publication.

Ethical issues

This investigation has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO website (ID: CRD420261394310) and Research Registry with Unique Identifying Number [UIN] of reviewregistry2104. Besides, the authors have observed ethical issues (including plagiarism, data fabrication, and double publication).

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