

Incidence of pregnancy-associated acute kidney injury in low- and middle-income countries: a meta-analysis

Phu Nguyen Trong Tran,^a Anyarin Wannakittirat,^b Valerie Luyckx,^c Kate Wiles,^d Manjusha Yadla,^e Rajasekara Chakravarthi,^f Marlies Ostermann,^g Vin-Cent Wu,^h Ravindra L Mehtaⁱ & Nattachai Srisawat^a

Objective To conduct a systematic review and meta-analysis of pregnancy-associated acute kidney injury in low- and middle-income countries.

Method We searched the databases Cochrane Central Register of Controlled Trials, Embase, Google Scholar, OvidMedline, ProQuest and Scopus for articles published during 2013–2025 reporting the incidence, etiology and outcomes of the condition in low- and middle-income countries. We conducted a meta-analysis of the studies that used the diagnostic criteria of the Kidney Disease: Improving Global Outcomes organization. We conducted subgroup analyses and a meta-regression to explore sources of heterogeneity.

Findings We reviewed 43 studies and included 40 in our meta-analysis, covering 424 081 pregnancies in 15 low- and middle-income countries. We observed a pooled incidence of 91 cases (95% confidence interval, CI: 63–133) per 10 000 pregnancies, highest in studies conducted in the World Health Organization African Region (254; 95% CI: 152–421). We estimated case fatality of 10.8% (95% CI: 7.6–15.3) and neonatal death or stillbirth in 29.8% of cases (95% CI: 24.2–36.1). We observed that the condition was associated with 18.8-fold higher odds of maternal death (95% CI: 10.0–35.5) and 4.6-fold higher odds of adverse fetal outcomes (95% CI: 2.1–10.0). We identified pre-eclampsia (44.1%), haemorrhage (26.2%) and sepsis (16.5%) as the leading etiologies.

Conclusion Pregnancy-associated acute kidney injury is a significant maternal health concern in low- and middle-income countries. By providing more resources to prevent the common etiologies and expand the availability of antenatal care, its deleterious effects on maternal and fetal outcomes can be reduced.

Abstracts in **عربي**, **中文**, **Français**, **Русский** and **Español** at the end of each article.

Introduction

Pregnancy-associated acute kidney injury is defined as a sudden decline in kidney function during pregnancy or the postpartum period (6–8 weeks after giving birth). Accounting for 1% of all acute kidney injury admissions globally in women of reproductive age, dialysis administered for severe acute kidney injury is most often for the pregnancy-associated type.¹ The consequences of the condition are severe, with case fatality rates ranging from 9.3% (29/313) in Tunisia to 28.3% (13/46) in Morocco, and increased risks of preterm birth, stillbirth and neonatal intensive care admissions.² Given its significant impact, pregnancy-associated acute kidney injury is widely recognized as an urgent public health issue, as a major contributor to maternal and fetal morbidity and mortality.³

The burden of pregnancy-associated acute kidney injury is higher in low- and middle-income countries compared to high-income countries. Large registry-based studies conducted in Canada (2003–2010)⁴ and the United States of America (1999–2011)⁵ have reported an incidence of approximately 2–8 cases per 10 000 pregnancies. In contrast, studies in Benin, China, India, Morocco and South Africa have shown incidences from 7 to over 1000 cases per 10 000

pregnancies.^{6–12} Although case fatality rates in women with the condition is estimated to be around 3% in high-income countries, this figure has exceeded 20% in India, Nigeria and the United Republic of Tanzania.^{5,13–15} This disparity is further reflected in the distribution of common etiologies. For example, infection-related severe maternal outcomes are reported to be more than 15 times more frequent in low- and middle-income countries than in high-income countries,¹⁶ and maternal deaths as a result of pre-eclampsia are significantly more prevalent in socioeconomically disadvantaged populations of low- and middle-income countries.¹⁷ These findings highlight the need for focused research and public health interventions to address pregnancy-related acute kidney injury in low- and middle-income countries.

Despite increasing awareness of the health burden, research in low- and middle-income countries remains limited; in contrast to high-income countries, most do not have a national registry for the condition, and most studies have been small-scale cohort studies or case reports.¹⁸ The true burden of the condition in lower-income countries is difficult to determine because of inconsistent study design, variable diagnostic criteria and heterogeneous reporting. Although a previous review estimated global incidence, the

^a Center of Excellence in Critical Care Nephrology and Division of Nephrology, Faculty of Medicine, Chulalongkorn University, Bangkok 10400, Thailand.

^b Division of Nephrology, Faculty of Medicine, Naresuan University Hospital, Phitsanulok, Thailand.

^c University Children's Hospital, University of Zurich, Zurich, Switzerland.

^d Department of Maternal Medicine, Queen Mary University of London, London, England.

^e Department of Nephrology, Gandhi Medical College, Hyderabad, India.

^f Nephrology and Transplant Services, Yashoda Hospitals, Hyderabad, India.

^g Department of Critical Care and Nephrology, King's College London, London, England.

^h Division of Nephrology, Department of Internal Medicine, National Taiwan University Hospital, Taipei, Taiwan.

ⁱ Division of Nephrology, University of California San Diego, San Diego, United States of America.

Correspondence to Nattachai Srisawat (email: nattachai.sr@chula.ac.th).

(Submitted: 18 December 2024 – Revised version received: 8 April 2025 – Accepted: 5 May 2025 – Published online: 24 June 2025)

burden and etiology specifically for low- and middle-income countries were unavailable.¹⁹ One review highlighted clinical profiles and progress in low- and middle-income countries, but lacked a systematic evaluation of the evidence.¹ More importantly, no previous work has attempted to address interstudy variability and ensure generalizability by comprehensively assessing incidence and outcomes in low- and middle-income countries using harmonized diagnostic criteria.

In this study we seek to address these knowledge gaps by conducting a comprehensive meta-analysis of pregnancy-associated acute kidney injury in low- and middle-income countries. Using criteria defined by the Kidney Disease: Improving Global Outcomes organization to standardize case definitions across diverse populations, we aim to characterize the burden of the condition by assessing its incidence and impact on maternal and fetal outcomes, as well as identify potential opportunities for intervention by analysing etiologies and modifiable health-care factors.

Methods

Outcome of interest

The primary outcome of interest from our meta-analysis is the burden of pregnancy-associated acute kidney injury, assessed by its incidence and associated maternal and fetal outcomes. We define incidence as the total number of new cases observed per 10 000 pregnancies during the study period. Maternal outcomes include renal replacement therapy, chronic or end-stage kidney disease and death. Fetal outcomes include neonatal death and stillbirth.

Secondary outcomes include etiologies, as defined by the original studies. Sepsis encompasses post-abortion and puerperal infections; pre-eclampsia spectrum includes gestational hypertension, pre-eclampsia, severe pre-eclampsia and eclampsia, as well as haemolysis, elevated liver enzymes and low platelet count (HELLP syndrome); and obstetric haemorrhage includes both antepartum, intrapartum and postpartum bleeding.

Search

We registered our systematic review and meta-analysis protocol on PROSPERO (CRD42024512357). We conducted a comprehensive search for both peer-

reviewed publications and unpublished studies in the databases Cochrane Central Register of Controlled Trials, Embase, Google Scholar, OvidMedline, ProQuest and Scopus, published or released during the period 1 January 2013 to 15 March 2025, on 16 March 2025. Our search strategy was based on the two primary concepts of acute kidney injury and pregnancy, incorporating various keyword variations (details available in online repository).²⁰

We screened observational studies conducted in low- and middle-income countries (as defined by the World Bank)²¹ during 2013–2023 that reported the primary outcome of the incidence of pregnancy-associated acute kidney injury in any language. To ensure generalizability, we required that studies selected for review included both pregnancy and the postpartum period. We excluded studies that focused solely on subgroups (e.g. sepsis or pre-eclampsia), lacked diagnostic criteria for pregnancy-associated acute kidney injury or defined the condition solely by the need for dialysis. Summaries of the excluded studies are provided in the online repository.²⁰

We uploaded all resulting citations to Covidence (Veritas Health Innovation Ltd, Melbourne, Australia), where duplicates were automatically removed. Two authors independently screened titles and abstracts, with a third author resolving disagreements. We assessed full texts according to our inclusion and exclusion criteria. We extracted data including study details (authors, year, duration, country, design, setting), demographics (age, pregnancy duration), sample size, diagnostic criteria, etiology and outcomes. Two authors performed data extraction independently, and a third author verified the extracted data.

Exploration of heterogeneity

To explore factors contributing to heterogeneity in the pooled analysis, we supplemented study-level characteristics (e.g. design and quality) with country-level socioeconomic and geographical metadata. Geographically, we grouped studies by country and by World Health Organization (WHO) regions.²² We defined socioeconomic context using the World Bank income classification at the time of each study.²¹ We also categorized studies by national health-care expenditure as a percentage of gross domestic product (GDP)

– either less than 5% or 5–10% – based on WHO statistics.^{23,24} For antenatal care coverage, we used United Nations Children's Fund data on the percentage of women aged 15–49 years receiving at least one or at least four antenatal visits,²⁵ categorized as less than 75%, or 75% or more.

We used the Joanna Briggs Institute critical appraisal tools for studies reporting prevalence or incidence data to assess the risk of bias and study quality.²⁶ According to a score ranging from 0 to 9, we classified study quality as low (0–3), medium (4–6) and high (7–9; online repository).²⁰

Data analysis

We conducted a meta-analysis of proportions using the `metaprop` function of the `meta` and `metafor` packages of RStudio version 4.3.1 (Posit PBC, Boston, USA), which applies a random-intercept logistic regression (generalized linear mixed model) to logit-transformed proportions. We calculated pooled odds ratios, 95% confidence intervals (CIs) and *P*-values for binary outcomes (maternal or fetal mortality) by the inverse variance method and Wald *z*-test of the `metabin` function of RStudio. We based all analyses on random-effect models to account for between-study variability.

We assessed heterogeneity using the *I*² statistic, with values of 70% and higher indicating substantial heterogeneity. To explore potential sources, we conducted subgroup analyses (for study- and country-level categorical factors) and meta-regression (for the middle year of data collection as a continuous moderator) using the *Q*-test (χ^2 test) and Wald *z*-test, respectively. We performed an interaction term analysis between the middle year and country socioeconomic factors using a multivariable meta-regression of the `metareg` function in RStudio, adjusted for study design and quality.

Our sensitivity analyses included leave-one-out influence analysis, and a stepwise exclusion of low- and medium-quality studies and those with sample sizes smaller than 5000 and 10 000. We compared the pooled estimates and *I*² values to assess robustness.

We could not disaggregate data by age because original data were unavailable.

Results

Study population

After screening 4950 records, we assessed 174 articles for eligibility; on excluding 131 articles, we reviewed 43 studies (Fig. 1). Our included studies were published from 2015 to 2024 and reported the incidence of pregnancy-associated acute kidney injury from 2013 to 2023. Most studies were conducted in India (19);^{6,7,15,27–42} five were from China^{8,43–46} and three from Egypt.^{47–49} Two studies were conducted in each of Nepal,^{50,51} Nigeria^{13,52} and the United Republic of Tanzania;^{14,53} and a single study was conducted in each of Bangladesh,⁵⁴ Benin,¹² Chad,⁵⁵ Ethiopia,⁵⁶ Guinea,⁵⁷ Kenya,⁵⁸ Malawi,⁵⁹ the Philippines,⁶⁰ Romania⁶¹ and Somalia⁶² (Table 1).

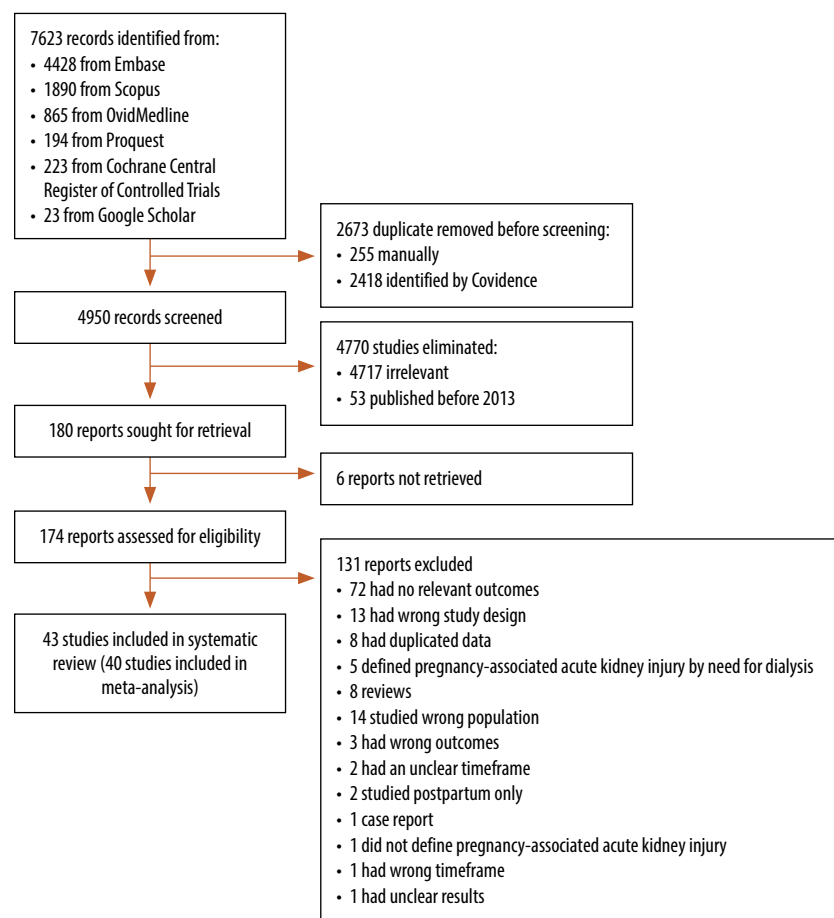
We observed that diagnostic criteria for pregnancy-associated acute kidney injury included those of the Kidney Disease: Improving Global Outcomes organization in 40 studies^{6–8,12–15,27,29–42,44–53,55–62} and serum creatinine concentration in pregnancy in three studies.^{28,43,54} We summarize details regarding diagnostic criteria conversion in the online repository.²⁰ In assigning study quality, the most common reasons for point deduction were insufficient information and data analysis for patients without pregnancy-associated acute kidney injury (Table 1). To ensure comparability between studies, we only included the 40 studies using the diagnostic criteria of the Kidney Disease: Improving Global Outcomes organization in our meta-analysis.

Incidence

We analysed a total of 3201 cases of pregnancy-induced acute kidney injury from 424 081 pregnancies across the 40 studies included in the meta-analysis. We observed a pooled incidence of 91 cases per 10 000 pregnancies (95% CI: 63–133; I^2 : 99.1%; Fig. 2), ranging from 7⁷ in India to 1173¹² in Benin per 10 000 pregnancies (Table 1).

We noted that prospective studies (118 cases per 10 000 pregnancies; 95% CI: 79–177; I^2 : 97.6%)^{6,12–15,30–37,39–42,47,48,50–53,55,57–59} had higher estimates than retrospective studies (56; 95% CI: 28–112; I^2 : 99.6%),^{7,8,13,27,29,38,44–46,49,56,60–62} although studies recruiting only intensive care unit patients reported lower estimates (44; 95% CI: 3–532; I^2 : 99.7%)^{7,52} than studies recruiting

Fig. 1. Flowchart of the selection of studies on pregnancy-associated acute kidney injury in low- and middle-income countries



patients from all wards (95; 95% CI: 66–137; I^2 : 99.1%).^{6,8,12–15,27,29–42,44–51,53,55–62}

When studies are pooled by country, we observed the lowest incidence per 10 000 pregnancies in Nepal (23; 95% CI: 17–31),^{50,51} Somalia (33; 95% CI: 22–46)⁶² and Romania (45; 95% CI: 27–71);⁶¹ and the highest in Benin (1173; 95% CI: 843–1574),¹² Chad (452; 95% CI: 343–483)⁵⁵ and Nigeria (409; 95% CI: 227–729; I^2 : 97.5%; Table 2).^{13,52} Among the WHO regions, we observed the highest incidence in pooled studies based in the African Region (254; 95% CI: 152–421; I^2 : 98.4%)^{12–14,52,53,55–59} and the Western Pacific Region (116; 95% CI: 41–323; I^2 : 99.8%).^{8,44–46,60} We noted that pooled incidence per 10 000 pregnancies in the South-East Asia and Eastern Mediterranean regions were similar at 59 (95% CI: 36–99; I^2 : 98.2%)^{6,7,15,27,29–42,50,51} and 52 (95% CI: 36–76; I^2 : 84.7%),^{47–49,62} respectively (Table 2).

Although our leave-one-study-out analysis highlighted the stability of the pooled incidence estimate

(85–96 cases per 10 000 pregnancies; I^2 : 98.6–99.2%; online repository),²⁰ the exclusion of low-quality and then both low- and medium-quality studies increased the estimate to 94 (95% CI: 64–139; I^2 : 99.2%)^{6,8,12–15,27,29–33,35–42,44–53,55,56,58–62} and 144 (95% CI: 86–241; I^2 : 99.5%),^{6,8,13,27,31,37,39,41,44–46,52,53,56,58,59} respectively, suggesting higher estimates from higher-quality studies. We observed that the estimates also decreased substantially to 51 (95% CI: 33–78; I^2 : 99.4%)^{7,8,27,29,32–41,44–47,50,51,53,56,62} and 42 (95% CI: 21–81; I^2 : 99.7%)^{7,8,27,29,32,39,41,44,46,47,50,56} when only considering studies with at least 5000 or 10 000 pregnancies, respectively (Table 2).

We did observe trends in socioeconomic factors: incidence was higher in low-income countries (113; 95% CI: 48–264; I^2 : 98.6%)^{12,50,51,53,55–57,59,62} than in lower-middle- (84; 95% CI: 54–131; I^2 : 98.4%)^{6,7,13–15,27,29–42,47–49,52,58,60} and upper-middle-income countries (94; 95% CI: 32–278; I^2 : 99.8%),^{8,44–46,61} but these lacked statistical significance.

Table 1. **Characteristics of the studies included in a systematic review and meta-analysis of pregnancy-associated acute kidney injury in low- and middle-income countries, published during 2015–2024**

Study	Country	Study period, study design ^a	Study period (months)	Sample size (no. pregnancies)	No. of cases ^b	Incidence per 10 000 pregnancies	Study quality ^c
Bhargava et al., 2015 ⁵¹	India	2013–2014	12	371	21	566	7
Paudyal et al., 2015 ⁵¹	Nepal	2013–2014	18	7 108	15	21	6
Hounkponou et al., 2017 ¹²	Benin	2016–2016	6	324	38	1173	6
Huang & Chen, 2017 ⁴³	China	2013–2017 ^d	90	42 173	343 ^e	81	7
Chitale et al., 2018 ³⁰	India	2014–2017	48	1 057	26	246	4
Cooke et al., 2018 ⁵⁹	Malawi	2015–2015	4	2 300	26	113	8
Gao et al., 2018 ⁴⁴	China	2014–2017 ^d	42	15 637	82	52	7
Prakash et al., 2018 ³¹	India	2014–2016	20	4 741	132	278	7
Sharma et al., 2018 ¹⁵	India	2017–2017	6	1 600	22	138	5
Ganesh & Soujanya, 2019 ³²	India	2016–2018	28	18 000	36	20	5
Kivai et al., 2019 ⁵⁸	Kenya	2018–2018	2	2 068	66	319	7
Liu et al., 2019 ⁸	China	2013–2015 ^d	36	10 920	720	659	9
Thakur et al., 2019 ⁵⁰	Nepal	2015–2015	12	11 490	28	24	6
Bah et al., 2020 ⁵⁷	Guinea	2018–2019	6	2 438	56	230	3
Elshinnawy et al., 2020 ⁴⁷	Egypt	2017–2017	12	13 050	78	60	6
Gayathiri et al., 2020 ³³	India	2018–2019	12	9 921	18	18	6
Papegowda et al., 2020 ⁷	India	2014–2019 ^d	60	50 735	36	7	3
Saini et al., 2020 ³⁴	India	2015–2016	24	5 645	81	143	3
Gaber et al., 2021 ⁴⁸	Egypt	2017–2019	24	4 500	40	89	3
Kanmani et al., 2021 ³⁵	India	2020–2020	12	9 099	21	23	4
Li et al., 2021 ⁴⁵	China	2015–2018 ^d	48	6 512	136	209	7
Meca et al., 2021 ⁶¹	Romania	2020–2021 ^d	20	4 000	18	45	6
Li et al., 2022 ⁴⁶	China	2013–2020 ^d	84	71 763	157	22	7
Mandal et al., 2022 ³⁷	India	2021–2021	12	9 270	79	85	7
Praba & Gomathi, 2022 ³⁸	India	2020–2021 ^d	24	9 444	34	36	6
Ruggajo et al., 2022 ⁵³	United Republic of Tanzania	2015–2016	6	5 448	99	182	9
Sachan et al., 2022 ³⁹	India	2019–2020	16	14 702	150	102	7
Abderraman et al., 2023 ⁵⁵	Chad	2020–2020	6	1 238	56	452	5
Anitha et al., 2023 ⁴⁰	India	2020–2020	12	7 409	104	140	5
Anvar et al., 2023 ²⁷	India	2015–2020 ^d	52	33 403	70	21	7
Faisal et al., 2023 ⁵⁴	Bangladesh	2018–2019	12	351	32 ^e	912	5
Kharkongor et al., 2023 ⁴¹	India	2022–2022	12	10 138	110	109	7
Rage et al., 2023 ⁶²	Somalia	2020–2022 ^d	24	9 457	31	33	6
Rajanna et al., 2023 ⁴²	India	2018–2019	12	2 650	42	158	5
Thakur et al., 2023 ³⁶	India	2018–2019	12	6 024	47	78	6
Berhe et al., 2024 ⁵⁶	Ethiopia	2017–2021 ^d	60	27 350	176	64	7
Habib et al., 2024 ¹³	Nigeria	2021–2023 ^d	24	1 647	103	625	7
Ismael et al., 2024 ⁴⁹	Egypt	2022–2023 ^d	18	4 390	18	41	6
Kamal, 2024 ²⁸	India	2022–2023 ^d	12	21 234	172 ^e	81	7
Mahalingam et al., 2024 ²⁹	India	2019–2019 ^d	12	16 469	19	12	6
Reston & Ti, 2024 ⁶⁰	Philippines	2019–2021 ^d	36	3 556	46	129	6
Shija et al., 2024 ¹⁴	United Republic of Tanzania	2019–2023	48	4 007	51	127	6
Waziri et al., 2024 ⁵²	Nigeria	2019–2022	34	4 200	113	269	8

^a Study design prospective, unless otherwise indicated.^b Pregnancy-associated acute kidney injury diagnosed according to the definitions included in the online repository.³⁰ Unless otherwise indicated, all studies used criteria defined by: Kidney Disease: Improving Global Outcomes; Acute Kidney Injury Network (AKIN); and/or Risk, Injury, Failure, Loss of kidney function, End-stage kidney disease (justifying both acute elevation of serum creatinine and urine output).^c We used the Joanna Briggs Institute critical appraisal tools for studies reporting prevalence or incidence data to assess the risk of bias and study quality.²⁶ We deemed a score of 0–3 as low quality, 4–6 as medium and 7–9 as high.^d Study design retrospective.^e Pregnancy-associated acute kidney injury diagnosed according to serum creatinine only (i.e. not included in meta-analysis).

Countries in which health-care expenditure was less than 5% of GDP had higher estimates (94; 95% CI: 60–147; I^2 : 99.2%)^{6–8,12–15,27,29–42,44,49,51–53,56–58,62} compared to countries spending 5–10% of GDP on health care (82; 95% CI: 44–152; P : 98.7%).^{45–48,50,55,59–61} Finally, we observed that incidence was lower in countries in which 75% or more of pregnant women received at least one antenatal care visit (81; 95% CI: 55–119; I^2 : 99.2%)^{6–8,14,15,27,29–42,44–50,53,57–60} compared to countries in which less than 75% of pregnant women received at least one antenatal care visit (146; 95% CI: 54–390; I^2 : 99.1%; Table 2).^{12,13,51,52,55,56,61,62}

Maternal and fetal outcomes

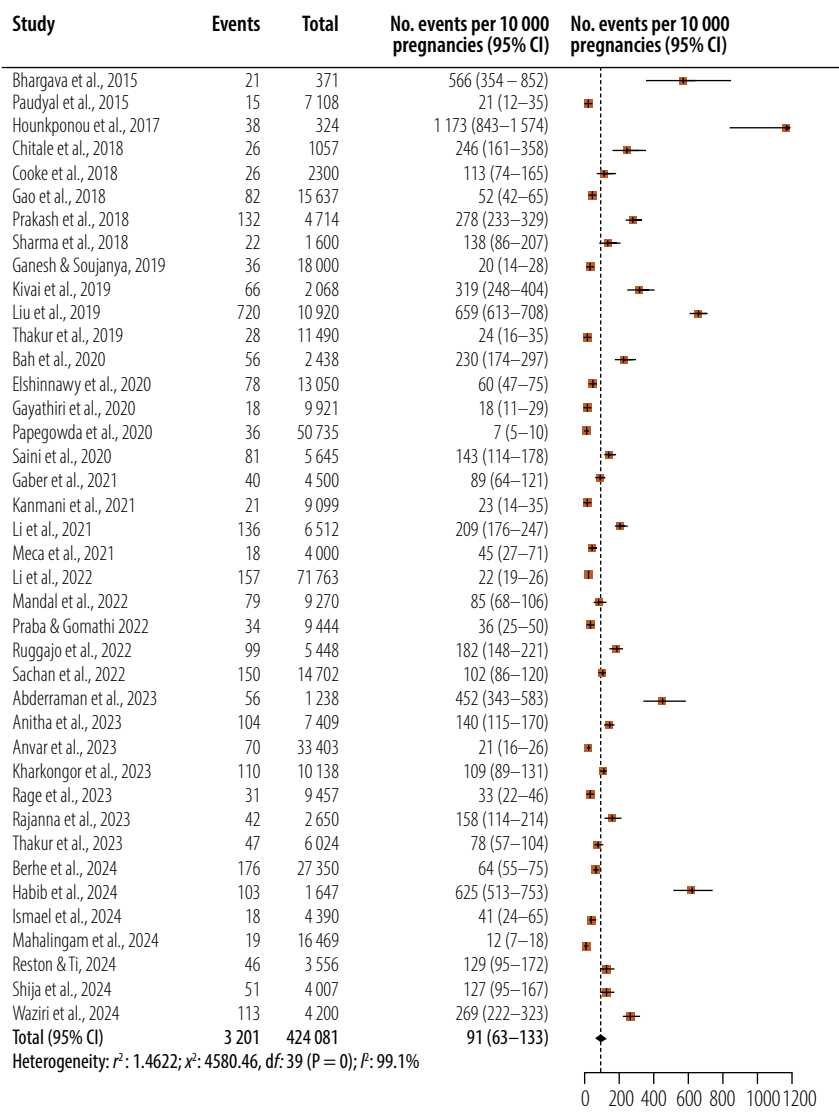
The incidence of pregnancy-associated acute kidney injury significantly affected maternal morbidity and both maternal and fetal outcomes. Dialysis was required in 29.1% of cases (95% CI: 18.6–42.6; P : 92.9%),^{7,8,13–15,27,30–42,44–53,55,56,59–62} while 19.1% (95% CI: 11.8–29.4; I^2 : 88.4%)^{6,13,15,30,32,34,36,38,39,41,44,47,48,51,53,55–57,59,60,62} progressed to chronic or end-stage kidney disease. We estimated maternal mortality from the condition at 8 per 10 000 pregnancies (95% CI: 5–13; P : 92.3%),^{6–8,13–15,27,29–42,44,45,47–53,55–62} accounting for 10.8% (95% CI: 7.6–15.3; I^2 : 85.1%) of all cases of pregnancy-associated acute kidney injury. Neonatal death or stillbirth occurred in 29.8% of all cases (95% CI: 24.2–36.1; P : 81.6%; Table 3).^{6,8,15,27,29–36,38–40,42,44–46,48,49,51–53,55–62} Compared with pregnancies without the condition, having pregnancy-associated acute kidney injury was associated with a significant 18.8-fold higher odds of maternal death (95% CI: 10.0–35.5; I^2 : 0.0%)^{8,52,61} and a 4.6-fold higher odds of adverse fetal outcomes (95% CI: 2.1–10.0; P : 69.0%; Fig. 3).^{6,52,53,59,61}

We observed reduced heterogeneity on conducting a subgroup analysis by country and WHO region (lowest I^2 = 0.0% and 66.8%, respectively), with the highest maternal and fetal mortality in the African Region of 13 (95% CI: 4–44) and 49 (95% CI: 24–100) deaths per 10 000 pregnancies, respectively. Other socioeconomic factors did not significantly explain heterogeneity (online repository).²⁰

Etiologies

Thirty-three studies^{7,8,13–15,27,29–32,34–41,44–46,48–53,55,56,59–62} reported the etiology or risk factors of pregnancy-associated

Fig. 2. Study events and pooled incidence of pregnancy-associated acute kidney injury in low- and middle-income countries



CI: confidence interval.

acute kidney injury. However, only eight studies specified diagnostic criteria (online repository).²⁰ The most common causes were pre-eclampsia (44.1%; 95% CI: 36.6–52.0; P : 89.8%),^{7,8,13–15,27,29–32,34–41,44–46,48–53,55,56,59–62} haemorrhage (26.2%; 95% CI: 21.8–31.3; P : 81.2%)^{7,13–15,27,29–32,34–41,44–46,48–53,55,56,59–62} and sepsis (16.5%; 95% CI: 11.4–23.4; P : 92.0%),^{7,8,13–15,27,29–32,34–41,44–46,48–53,55,56,59–62} corresponding to 31 (95% CI: 20–48; P : 97.9%), 18 (95% CI: 12–26; P : 95.9%) and 11 (95% CI: 7–18; P : 93.8%) cases per 10 000 pregnancies, respectively (Table 3). Heterogeneity was high (I^2 : 81.2–97.9%), prompting further subgroup analyses. Incidences varied by country and WHO region, with sepsis- and pre-eclampsia-related

pregnancy-associated acute kidney injury highest in Nigeria and Chad, respectively (online repository).²⁰

Socioeconomic factors and trend interaction

Although we observed a slight decline in the overall trend of pregnancy-associated acute kidney injury from 2013 to 2023 (using the Wald z -test P -value > 0.05), multivariable meta-regression revealed different trends across subgroups. Among the WHO regions, only the studies conducted in the African Region showed a slight increase (studies conducted in the South-East Asia, Eastern Mediterranean and Western Pacific regions showed declines). By income group, studies conducted in upper-mid-

Table 2. Heterogeneity in pregnancy-associated acute kidney injury in low- and middle-income countries

Characteristic (P-value)	No. studies in meta-analysis	No. cases	No. pregnancies	Pooled incidence per 10 000 pregnancies (95% CI)	P, %
Overall	40 ^{6-8,12-15,27,29-42,44-53,55-62}	3 201	424 081	91 (63-133)	99.1
Study design (0.0689)					
Prospective	26 ^{6,12-15,30-37,39-42,47,48,50-53,55,57-59}	1 555	158 798	118 (79-177)	97.6
Retrospective	14 ^{7,8,13,27,29,38,44-46,49,56,60-62}	1 646	424 081	56 (28-112)	99.6
Recruiting site (0.5544)					
Intensive care unit	2 ^{7,52}	149	54 935	44 (3-532)	99.7
All wards	38 ^{6,8,12-15,27,29-42,44-51,53,55-62}	3 052	369 146	95 (66-137)	99.1
WHO region (< 0.001)					
African	10 ^{12-14,52,53,55-59}	784	51 020	254 (152-421)	98.4
South-East Asia	20 ^{6,7,15,27,29-42,50,51}	1 091	229 276	59 (36-99)	98.2
European	1 ⁶¹	18	4 000	45 (27-71)	-
Eastern Mediterranean	4 ^{47-49,62}	167	31 397	52 (36-76)	84.7
Western Pacific	5 ^{8,44-46,60}	1 141	108 388	116 (41-323)	99.8
Country (< 0.001)					
Benin	1 ¹²	38	324	1 173 (843-1 574)	-
Chad	1 ⁵⁵	56	1 238	452 (343-583)	-
China	4 ^{8,44-46}	1 095	104 832	113 (31-405)	99.8
Egypt	3 ⁴⁷⁻⁴⁹	136	21 940	61 (45-84)	75.9
Ethiopia	1 ⁵⁶	176	27 350	64 (55-75)	-
Guinea	1 ⁵⁷	56	2 438	230 (174-297)	-
India	18 ^{6,7,15,27,29-42}	1 048	210 678	66 (38-114)	98.3
Kenya	1 ⁵⁸	66	2 068	319 (248-404)	-
Malawi	1 ⁵⁹	26	2 300	113 (74-165)	-
Nepal	2 ^{50,51}	43	18 598	23 (17-31)	0.0
Nigeria	2 ^{13,52}	216	5 847	409 (227-729)	97.5
Philippines	1 ⁶⁰	46	3 556	129 (95-172)	-
Romania	1 ⁶¹	18	4 000	45 (27-71)	-
Somalia	1 ⁶²	31	9 457	33 (22-46)	-
United Republic of Tanzania	2 ^{14,53}	150	9 455	155 (121-198)	76.9
Income level (0.8404)					
Upper-middle	5 ^{8,44-46,61}	1 113	108 832	94 (32-278)	99.8
Lower-middle	26 ^{6,7,13-15,27,29-42,47-49,52,58,60}	1 563	248 096	84 (54-131)	98.4
Low	9 ^{12,50,51,53,55-57,59,62}	525	67 153	113 (48-264)	98.6
Percentage of GDP spent on health care (0.7249)					
5-10	9 ^{45-48,50,55,59-61}	585	118 409	82 (44-152)	98.7
< 5	31 ^{6-8,12-15,27,29-42,44,49,51-53,56-58,62}	2 616	305 672	94 (60-147)	99.2
Percentage of women receiving at least one antenatal care visit (0.2855)					
≥ 75	32 ^{6-8,14,15,27,29-42,44-50,53,57-60}	2 651	368 757	81 (55-119)	99.2
< 75	8 ^{12,13,51,52,55,56,61,62}	550	55 324	146 (54-390)	99.1
Percentage of women receiving at least four antenatal care visits (0.9856)					
≥ 75	8 ^{8,12,44-49,60}	1 261	130 328	91 (45-183)	99.7
< 75	32 ^{6,7,12-15,27,29-42,50-53,55-59,61,62}	1 924	293 753	91 (59-141)	98.5
Sensitivity analysis: study quality					
Medium- and high-quality only	36 ^{6,8,12-15,27,29-33,35-42,44-53,55,56,58-62}	2 988	360 763	94 (64-139)	99.2
High-quality only	16 ^{6,8,13,27,31,37,39,41,44-46,52,53,56,58,59}	2 240	220 470	144 (86-241)	99.5
Sensitivity analysis: sample size					
≥ 5 000 pregnancies	23 ^{7,8,27,29,32-41,44-47,50,51,53,56,62}	2 327	378 994	51 (33-78)	99.4
≥ 10 000 pregnancies	12 ^{7,8,27,29,32,39,41,44,46,47,50,56}	1 662	293 657	42 (21-81)	99.7

CI: confidence interval; GDP: gross domestic product; WHO: World Health Organization.

Table 3. Etiology and maternal and fetal outcomes in pregnancy-associated acute kidney injury in low- and middle-income countries

Etiology or outcome	No. studies reporting an event	No. events within relevant studies	Pregnancy-associated acute kidney injury			Pregnancies		
			No. cases within relevant studies	Pooled prevalence (95% CI)	I ² , %	No. pregnancies within relevant studies	Pooled prevalence per 10 000 pregnancies (95% CI)	I ² , %
Outcome								
Requiring haemodialysis	35 ^{7,8,13-15,27,30-42,44-53,55,56,59-62}	716	3001	29 (19-43)	92.9	402 411	18 (12-29)	96.6
Maternal mortality	38 ^{5-8,13-15,27,29-42,44,45,47-53,55-62}	350	3006	11 (8-15)	85.1	351 994	8 (5-13)	92.3
Progression to chronic or end-stage kidney disease	21 ^{6,13,15,30,32,34,36,38,39,41,44,47,48,51,53,55-57,59,60,62}	345	1335	19 (12-29)	88.4	160 710	18 (12-26)	92.8
Neonatal death or stillbirth	32 ^{6,8,15,27,29-36,38-40,42,44-46,48,49,51-53,55-62}	785	2678	30 (24-36)	81.6	323 420	24 (16-36)	97.0
Etiology								
Sepsis	33 ^{7,8,13-15,27,29-32,34-41,44-46,48-53,55,56,59-62}	537	2882	17 (11-23)	92.0	393 259	11 (7-18)	93.8
Pre-eclampsia	33 ^{7,8,13-15,27,29-32,34-41,44-46,48-53,55,56,59-62}	1317	2882	44 (37-52)	89.8	393 259	31 (20-48)	97.9
Haemorrhage	32 ^{7,13-15,27,29-32,34-41,44-46,48-53,55,56,59-62}	578	2162	26 (22-31)	81.2	382 339	18 (12-26)	95.9

CI: confidence interval.

dle-income countries exhibited a steep decline, whereas those in low-income countries showed a slight increase. Studies based in countries in which health-care spending was 5–10% of GDP demonstrated an increasing trend, while those in which health-care spending was less than 5% of GDP showed a decline. However, none of these interactions was statistically significant, with P -values of more than 0.05 (Fig. 4).

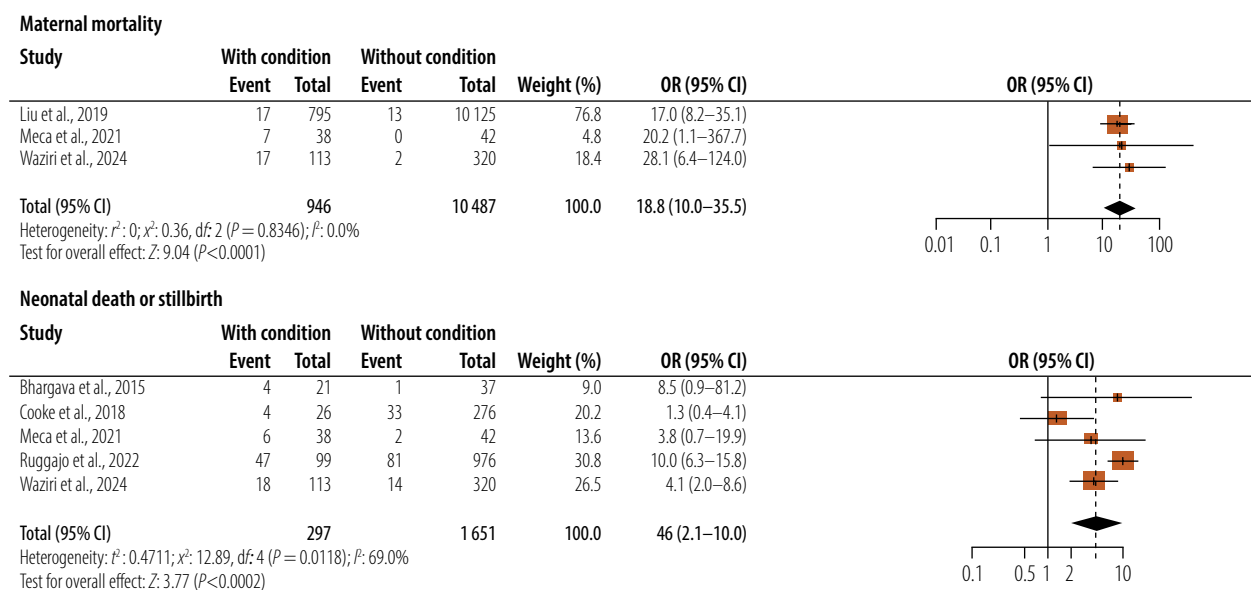
Notably, the trend in the incidence of pregnancy-associated acute kidney injury varied significantly by the availability of antenatal care. Countries in which 75% or more of pregnant women received at least four antenatal care visits showed a declining trend, while those in which less than 75% of pregnant women received at least four antenatal care visits exhibited an increasing trend ($P_{\text{interaction}} < 0.0001$; Fig. 4). This factor also had a significant moderating effect on related maternal and fetal mortality ($P_{\text{interaction}} < 0.0001$; online repository),²⁰ with a slower increase in maternal mortality and a sharper decline in neonatal death or stillbirth observed in countries in which 75% or more of pregnant women received at least four antenatal care visits. These findings remained robust in sensitivity analyses, including modelling as a continuous variable and adjusting for study design and quality (online repository).²⁰

Discussion

Our meta-analysis of pregnancy-associated acute kidney injury in low- and middle-income countries revealed a substantial burden. One quarter of women with the condition required dialysis, and one fifth progressed to chronic or end-stage kidney disease. One tenth of cases resulted in maternal death, and around one third in neonatal death or stillbirth.

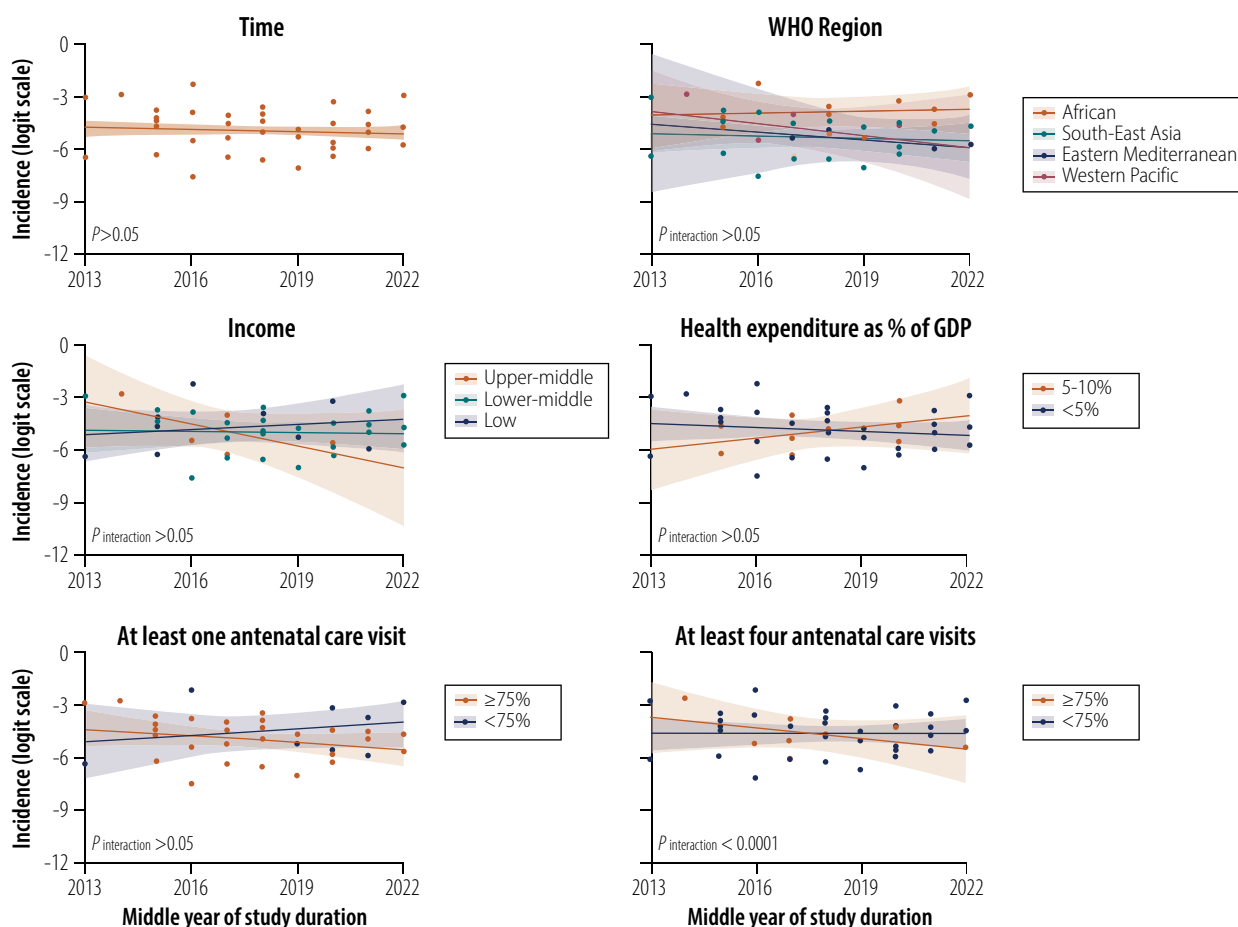
By extrapolating our findings to approximately 190 million pregnancies annually worldwide,⁶³ pregnancy-associated acute kidney injury may affect 1.7 million pregnancies and lead to more than 186 000 deaths in low- and middle-income countries. Our findings align with previous work that focused on specific regions. Case fatality rates reached 34.4% in Africa, with most women requiring intensive care and haemodialysis.⁶⁴ In Asia, case fatality rates varied between 7.7% (10/130) and 28.9% (24/83), and up to 50% (16/32)

Fig. 3. Individual study estimates and pooled effect of pregnancy-induced acute kidney injury on maternal mortality (upper) and neonatal death or stillbirth (lower) in low- and middle-income countries



CI: confidence interval; OR: odds ratio.

Fig. 4. Interaction between socioeconomic factors and middle year of data acquisition as moderators of the incidence of pregnancy-associated acute kidney injury in low- and middle-income countries



GDP: gross domestic product.

of women had an outcome of neonatal death or stillbirth.¹ A meta-analysis comparing nearly 8000 pregnancies with and without the condition found that acute kidney injury was associated with a more than fourfold increase in the risk of maternal death, a longer stay in intensive care by 2 days, a threefold increased incidence of stillbirth or perinatal death, and a birth weight lower by 740 g.² These results are consistent with WHO data showing a global maternal mortality of 223 deaths per 100 000 live births in 2020, with nearly 95% of maternal deaths occurring in low-resource settings.⁶⁵

Although our subgroup analysis did not show a noticeable difference in the incidence of pregnancy-associated acute kidney injury between low- and upper-middle-income countries, the gap is large when comparing with data from high-income countries. At 12 reported cases per 10 000 pregnancy-related hospitalizations in the USA,⁵ our pooled findings indicate an incidence of eight times higher for low- and middle-income countries and 20 times higher for countries within the WHO African Region. Similarly, our pooled proportion of cases receiving dialysis and maternal mortality are threefold higher than those reported in the USA (8.2%; 351/4300 and 4.0%; 170/4300, respectively).⁵

Systemic health-care disparities, inadequate access to prenatal care, delayed interventions, limited availability of kidney replacement therapy and other resource constraints are factors that likely drive the disproportionate burden in low- and middle-income countries. Low preparedness for acute kidney injury care, as highlighted in a recent report by the International Society of Nephrology, could also be a contributing factor. The report indicated that registries and advocacy groups are mostly unavailable, and nephrologists are alarmingly low in low-income countries.⁶⁶

We identified pre-eclampsia, haemorrhage and sepsis as leading etiologies, as well as an association between greater antenatal care coverage and decreasing incidence, consistent with the WHO publication on leading maternal mortality causes⁶⁷ as well as systematic reviews conducted in African and Asian countries.^{64,68} Fragmented prenatal care, delayed diagnosis and inadequate referral systems exacerbate these conditions, perhaps allowing them to progress to

acute kidney injury. The burden of infectious diseases also remains high in low- and middle-income countries, with conditions such as human immunodeficiency virus infection, malaria, leptospirosis and septic abortion being important contributors to pregnancy-associated acute kidney injury. Unsafe abortion practices, often resulting from restrictive reproductive health laws and limited access to contraception, are still prevalent in several low- and middle-income countries, and continue to lead to sepsis-related acute kidney injury during pregnancy.^{31,45} These challenges are rarely encountered in high-income countries, where reproductive health services are generally safer and more accessible. Nevertheless, the fact that these conditions are all deemed preventable or treatable offers important opportunities for improvement.

Our findings that higher antenatal care availability was significantly associated with lower incidence and improved maternal and fetal outcomes emphasize the importance of adequate antenatal care. Frequent antenatal care improves pregnancy-associated acute kidney injury outcomes through early detection, risk mitigation and timely intervention, and enables early management of hypertensive disorders such as pre-eclampsia via blood pressure monitoring, antihypertensives and preventive eclampsia therapy.⁶⁹ Prompt diagnosis of infections such as sepsis allows timely antibiotic treatment, reducing inflammation and kidney damage.⁷⁰ Antenatal care also mitigates haemorrhage risks by screening for anaemia, providing iron supplementation and implementing postpartum haemorrhage protocols to prevent hypovolemia-induced acute kidney injury.⁷¹

Structured antenatal care also improves fetal outcomes by reducing preterm births and low birth weight, both linked to complications of pregnancy-associated acute kidney injury. Studies show regular antenatal care attendees have lower risk of perinatal death as a result of better maternal health.⁵² Antenatal care also facilitates timely referrals to tertiary care, critical for accessing renal replacement therapy (although low- and middle-income countries often face dialysis shortages).⁷² By integrating risk stratification and patient education, antenatal care empowers women to seek care earlier, mitigating delays that

exacerbate the severity of pregnancy-associated acute kidney injury in low-resource settings.⁷³

Our study has several strengths. Our comprehensive literature review included all the main databases as well as several sources of grey literature. We minimized between-study variability and ensured generalizability by including only studies that used criteria defined by the Kidney Disease: Improving Global Outcomes organization. We explored the impact of geographic, socioeconomic and antenatal care factors on heterogeneity with our extensive subgroup analyses and meta-regression.

However, our study was limited by several factors. First, a potential source of heterogeneity among our reviewed studies is a variation in the definition of the pregnancy and postpartum period; for example, some studies included participants from 20 weeks of gestation to 6 weeks postpartum,^{12,59} although other studies only included participants up to the end of the immediate postpartum (i.e. 24 hours after giving birth)⁵⁷ or for 2 weeks postpartum.⁴⁸ Second, variability in denominators (e.g. total pregnancies, deliveries or live births) may have contributed to discrepancies. Third, although we attempted to include studies with harmonized condition definitions, Kidney Disease: Improving Global Outcomes criteria are not standard because serum creatinine is also known to be lowered during pregnancy; the true incidence of pregnancy-associated acute kidney injury could therefore be higher than estimated here.⁴³ Fourth, studies conducted retrospectively versus prospectively may have been subject to recall bias, although we attempted to address this by subgroup analysis and multivariable meta-regression adjustment. Fifth, only a subset of the studies defined the etiology of the condition, and these definitions were inconsistent. Finally, we were not able to assess high-risk subgroups (e.g. those with prior pregnancy-associated acute kidney injury, autoimmune conditions or kidney disease) because of limited access to original data.

We have demonstrated that pregnancy-associated acute kidney injury is a significant maternal health concern in low- and middle-income countries. By providing more resources to prevent the common etiologies and expand the availability of antenatal care, the burden of this condition and its effects

on maternal and fetal outcomes can be reduced. We anticipate that our findings will provide critical insights to inform targeted public health strategies, ultimately reducing preventable deaths in low-resource settings. ■

Acknowledgements

PNTT received the International Society of Nephrology (ISN)–Ravi Mehta grant for his fellowship at the King Chulalongkorn Memorial Hospital, Thailand. He is also affiliated to the De-

partment of Internal Medicine, Can Tho University of Medicine and Pharmacy, Can Tho, Viet Nam. VL is also affiliated to the Department of Public and Global Health, Epidemiology, Biostatistics and Prevention Institute, University of Zurich, Zurich, Switzerland; Renal Division, Brigham and Women's Hospital, Harvard Medical School, Boston, USA; and the Department of Paediatrics and Child Health, University of Cape Town, Cape Town, South Africa. KW is also affiliated to Barts Health NHS Trust,

London, United Kingdom of Great Britain and Northern Ireland. MG is also affiliated to Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom. NS is also affiliated to the Division of Nephrology, Department of Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand; and the Academy of Science, Royal Society of Thailand, Bangkok, Thailand.

Competing interests: None declared.

© 2025 The authors; licensee World Health Organization.

This is an open access article distributed under the terms of the Creative Commons Attribution IGO License (<http://creativecommons.org/licenses/by/3.0/igo/legalcode>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. In any reproduction of this article there should not be any suggestion that WHO or this article endorse any specific organization or products. The use of the WHO logo is not permitted. This notice should be preserved along with the article's original URL.

ملخص

معدل الإصابة الكلوية الحادة المرتبطة بالحمل في الدول ذات الدخل المنخفض والدخل المتوسط: تحليل تلوي
الغرض إجراء مراجعة منهجية وتحليل تلوي لإصابة الكلى الحادة المرتبطة بالحمل في الدول ذات الدخل المنخفض والدخل المتوسط. الطريقة قمنا بالبحث في قواعد بيانات Central Cochrane، Embase، و Google Scholar، و Ovid Medline، و ProQuest، و Scopus، عن مقالات نُشرت خلال الفترة 2013 إلى 2025، تتناول معدل الإصابة، وأسبابها، ونتائجها في الدول منخفضة ومتوسطة الدخل. وقمت بإجراء تحليل تلوي للدراسات التي استخدمت المعايير التشخيصية لمؤسسة "أمراض الكلى: مؤسسة تحسين النتائج العالمية". كما أجرينا تحليلات للمجموعات الفرعية، وتحولاً تلويًا لاستكشاف مصادر التباين. النتائج قمنا بمراجعة 43 دراسة، وأدرجنا 40 منها في تحليلنا التلوي، الذي غطى 424081 من حالات الحمل في 15 دولة منخفضة ومتوسطة الدخل. لاحظنا معدلًا مجمّعًا بلغ 91 حالة (بفاصل ثقة 95%: 63 إلى 133) لكل 10000 حالة حمل، وهو

أعلى معدل في الدراسات التي أجريت في منطقة أفريقيا التابعة لمنظمة الصحة العالمية (254 حالة؛ بفاصل ثقة 95%: 152 إلى 421). وقدّرنا معدل وفيات الأمهات بنسبة 10.8% (بفاصل ثقة 95%: 7.6 إلى 15.3) ووفاة حديثي الولادة أو ولادة جنين ميت في 29.8% من الحالات (بفاصل ثقة 95%: 24.2 إلى 36.1). ولاحظنا أن هذه الحالة ارتبطت بزيادة احتمالات وفاة الأم بمقدار 18.8 ضعفًا (بفاصل ثقة 95%: 10.0 إلى 5.5) وزيادة احتمالات حدوث نتائج سلبية على الجنين بمقدار 4.6 ضعفًا (بفاصل ثقة 95%: 2.1 إلى 10.0). حددنا مقدمات الارتعاج (44.1%)، والتليف (26.2%)، وتسهم الدم (16.5%) كأسباب رئيسية. النتائج تُعدّ إصابة الكلى الحادة المرتبطة بالحمل مصدر قلق كبير لصحة الأم في الدول ذات الدخل المنخفض والمتوسط. ومن خلال توفير المزيد من الموارد للوقاية من الأسباب الشائعة وتوسيع نطاق رعاية ما قبل الولادة، يُمكن تخفيف العبء والآثار على نتائج الأم والجنين.

摘要

中低收入国家妊娠相关急性肾损伤的发病率：荟萃分析

目的 旨在对中低收入国家的妊娠相关急性肾损伤进行系统评价和荟萃分析。

方法 我们搜索了 Central Cochrane、Embase、Google Scholar、Ovid Medline、ProQuest 和 Scopus 这六个数据库，以查找 2013 年至 2025 年期间发表的报告中低收入国家妊娠相关急性肾损伤发病率、病因和结局的文章。我们对采用改善全球肾脏病预后组织诊断标准的相关研究进行了荟萃分析。我们通过亚组分析和荟萃回归探索了异质性来源。

结果 我们回顾了共 43 项研究，并将其中 40 项研究（涵盖了 15 个中低收入国家中的 424,081 名孕妇）纳入了荟萃分析。我们发现，每 10,000 名孕妇中的合并发病率为 91 例【95% 置信区间 (CI)：63-133】，其中在世界卫生组织

非洲区域所开展研究中报告的发病率最高 (254 例；95% CI：152-421)。据我们估计，在所有病例中，孕产妇死亡率为 10.8% (95% CI：7.6-15.3)，新生儿死亡率或死产率为 29.8% (95% CI：24.2-36.1)。我们发现，妊娠相关急性肾损伤导致孕产妇死亡几率提高了 18.8 倍 (95% CI：10.0-35.5)，不良胎儿结局几率提高了 4.6 倍 (95% CI：2.1-10.0)。我们发现，主要的病因包括先兆子痫 (占 44.1%)、产后出血 (占 26.2%) 和脓毒症 (占 16.5%)。

结论 妊娠相关急性肾损伤是中低收入国家普遍存在的一个重大的孕产妇健康问题。中低收入国家可通过投入更多资源以避免常见病因和提高产检服务的可及性，从而减轻因孕产妇和胎儿出现不良结局而对该国所造成的负担并降低这些不良结局的影响。

Résumé

Incidence des lésions rénales aiguës associées à la grossesse dans les pays à revenu faible et intermédiaire: méta-analyse

Objectif Réaliser une revue systématique et une méta-analyse des lésions rénales aiguës associées à la grossesse dans les pays à revenu faible et intermédiaire.

Méthode Nous avons recherché dans les bases de données Central Cochrane, Embase, Google Scholar, OvidMedline, ProQuest et Scopus des articles publiés entre 2013 et 2025 faisant état de l'incidence, de l'étiologie et des résultats de cette affection dans les pays à revenu faible ou intermédiaire. Nous avons réalisé une méta-analyse des études qui appliquaient les critères de diagnostic de l'organisation Kidney Disease: Improving Global Outcomes. Nous avons effectué des analyses de sous-groupes et une méta-régression afin d'explorer les sources d'hétérogénéité.

Résultats Nous avons examiné 43 études et en avons inclus 40 dans notre méta-analyse, couvrant 424 081 grossesses dans 15 pays à revenu faible ou intermédiaire. Nous avons observé une incidence groupée de 91 cas (intervalle de confiance (IC) à 95%: 63–133) pour

10 000 grossesses, la plus élevée étant observée dans les études menées dans la région Afrique de l'Organisation mondiale de la Santé (254; IC à 95%: 152–421). Nous avons estimé la mortalité maternelle à 10,8% (IC à 95%: 7,6–15,3) et le décès néonatal ou la mortinaissance à 29,8% des cas (IC à 95%: 24,2–36,1). Nous avons observé que les lésions rénales aiguës étaient associées à un risque 18,8 fois plus élevé de décès maternel (IC à 95%: 10,0–35,5) et à un risque 4,6 fois supérieur d'issues défavorables pour le fœtus (IC à 95%: 2,1–10,0). Nous avons identifié la pré-éclampsie (44,1%), l'hémorragie (26,2%) et la septicémie (16,5%) parmi les principales étiologies.

Conclusion Les lésions rénales aiguës associées à la grossesse constituent un problème de santé maternelle important dans les pays à revenu faible ou intermédiaire. En fournissant davantage de ressources pour prévenir les étiologies courantes et en élargissant l'accès aux soins prénatals, il est possible de réduire le fardeau et les effets sur les résultats pour la mère et le fœtus.

Резюме

Частота случаев гестационного острого поражения почек в странах с низким и средним уровнем дохода: метаанализ

Цель Выполнить систематический обзор и метаанализ случаев гестационного острого поражения почек в странах с низким и средним уровнем дохода.

Методы Авторы провели поиск в базах данных Central Cochrane, Embase, Google Scholar, OvidMedline, ProQuest и Scopus на предмет статей, опубликованных в период с 2013 по 2025 год и содержащих данные о случаях, этиологии и исходах этого заболевания в странах с низким и средним уровнем дохода. Был проведен метаанализ исследований, в которых использовались диагностические критерии Международной организации по улучшению исходов заболеваний почек (Kidney Disease: Improving Global Outcomes). Был проведен анализ по подгруппам, а также была просчитана метарегрессия для выявления источников гетерогенности данных.

Результаты Из 43 рассмотренных исследований в метаанализ были включены 40, что позволило обобщить данные о 424 081 случае беременности в 15 странах с низким и средним уровнем дохода. Совокупная заболеваемость составила 91 случай (95%-й ДИ: 63–133) на 10 000 беременностей с наибольшими значениями

в тех исследованиях, которые проводились в Африканском регионе Всемирной организации здравоохранения (254; 95%-й ДИ: 152–421). Оценка материнской смертности была на уровне 10,8% (95%-й ДИ: 7,6–15,3), а смерть новорожденных или мертворожденность наблюдалась в 29,8% случаев (95%-й ДИ: 24,2–36,1). По наблюдениям авторов, изучаемое заболевание ассоциировалось с ростом вероятности смерти матери в 18,8 раза (95%-й ДИ: 10,0–35,5) и неблагоприятного исхода для плода в 4,6 раза (95%-й ДИ: 2,1–10,0). Авторы выяснили, что основными этиологиями были: преэклампсия (44,1%), кровотечение (26,2%) и сепсис (16,5%).

Вывод Гестационное острое поражение почек представляет серьезную угрозу материнскому здоровью в странах с низким и средним уровнем дохода. Выделение большего количества ресурсов на предотвращение распространенных этиологий данного заболевания и расширение доступности дородового ухода позволит снизить бремя и уменьшить влияние на исходы для матери и плода.

Resumen

Incidencia de la lesión renal aguda asociada al embarazo en países de ingresos bajos y medios: un metanálisis

Objetivo Realizar una revisión sistemática y un metanálisis sobre la lesión renal aguda asociada al embarazo en países de ingresos bajos y medios.

Método Se efectuó una búsqueda en las bases de datos Central Cochrane, Embase, Google Scholar, OvidMedline, ProQuest y Scopus de artículos publicados entre 2013 y 2025 que informaran sobre la incidencia, etiología y desenlaces de esta afección en países de ingresos bajos y medianos. Se llevó a cabo un metanálisis de los estudios que utilizaron los criterios diagnósticos de la organización Kidney Disease: Improving Global Outcomes. Se realizaron análisis por subgrupos y una metarregresión para explorar fuentes de heterogeneidad.

Resultados Se revisaron 43 estudios, de los cuales 40 fueron incluidos en el metanálisis, abarcando un total de 424 081 embarazos en 15 países de ingresos bajos y medios. Se observó una incidencia agrupada de 91 casos (intervalo de confianza, IC del 95%: 63–133) por cada

10 000 embarazos, con la cifra más alta en los estudios realizados en la Región de África de la Organización Mundial de la Salud (254; IC del 95%: 152–421). Se estimó una mortalidad materna del 10,8% (IC del 95%: 7,6–15,3) y una tasa de muerte neonatal o mortinatalidad en el 29,8% de los casos (IC del 95%: 24,2–36,1). Se identificó una asociación de esta afección con una probabilidad 18,8 veces mayor de muerte materna (IC del 95%: 10,0–35,5) y 4,6 veces mayor de desenlaces fetales adversos (IC del 95%: 2,1–10,0). Las principales etiologías fueron la preeclampsia (44,1%), las hemorragias (26,2%) y la sepsis (16,5%).

Conclusión La lesión renal aguda asociada al embarazo representa un problema relevante de salud materna en países de ingresos bajos y medios. La asignación de mayores recursos para prevenir las etiologías más frecuentes y ampliar la cobertura de la atención prenatal permitiría reducir su carga y sus efectos negativos sobre los desenlaces maternos y fetales.

References

- Davidson B, Bajpai D, Shah S, Jones E, Okyere P, Wearne N, et al. Pregnancy-associated acute kidney injury in low-resource settings: progress over the last decade. *Semin Nephrol.* 2022 Sep;42(5):151317. doi: <http://dx.doi.org/10.1016/j.semnephrol.2023.151317> PMID: 37011566
- Liu Y, Ma X, Zheng J, Liu X, Yan T. Pregnancy outcomes in patients with acute kidney injury during pregnancy: a systematic review and meta-analysis. *BMC Pregnancy Childbirth.* 2017 Jul 18;17(1):235. doi: <http://dx.doi.org/10.1186/s12884-017-1402-9> PMID: 28720086
- Jim B, Garovic VD. Acute kidney injury in pregnancy. *Semin Nephrol.* 2017 Jul;37(4):378–85. doi: <http://dx.doi.org/10.1016/j.semnephrol.2017.05.010> PMID: 28711077
- Mehrabadi A, Liu S, Bartholomew S, Hutcheon JA, Magee LA, Kramer MS, et al.; Canadian Perinatal Surveillance System Public Health Agency of Canada. Hypertensive disorders of pregnancy and the recent increase in obstetric acute renal failure in Canada: population based retrospective cohort study. *BMJ.* 2014 Jul 30;349 jul30 2:g4731. doi: <http://dx.doi.org/10.1136/bmj.g4731> PMID: 25077825
- Mehrabadi A, Dahhou M, Joseph KS, Kramer MS. Investigation of a rise in obstetric acute renal failure in the United States, 1999–2011. *Obstet Gynecol.* 2016 May;127(5):899–906. doi: <http://dx.doi.org/10.1097/AOG.0000000000001374> PMID: 27054929
- Bhargava V, Jain HK, Joshi P, Senga NS. Incidence of pregnancy related acute kidney injury (praki) a study done in three tertiary care centres. *Int J Multidisc Res Dev.* 2015;2(5):207–9. Available from: <https://www.allsubjectjournal.com/assets/archives/2015/vol2issue5/20.pdf> [cited 2025 Jun 6].
- Papegowda SH, Devi PK, Singh RL, Muruganadam A, Tochhawng ZL. Acute kidney injury in obstetrics: a five-year study in a tertiary centre. *Int J Reprod Contracept Obstet Gynecol.* 2019;9(1):113. doi: <http://dx.doi.org/10.18203/2320-1770.ijrcog20196007>
- Liu D, He W, Li Y, Xiong M, Wang L, Huang J, et al. Epidemiology of acute kidney injury in hospitalized pregnant women in China. *BMC Nephrol.* 2019 Feb 26;20(1):67. doi: <http://dx.doi.org/10.1186/s12882-019-1255-8> PMID: 30808326
- Liu YM, Bao HD, Jiang ZZ, Huang YJ, Wang NS. Pregnancy-related acute kidney injury and a review of the literature in China. *Intern Med.* 2015;54(14):1695–703. doi: <http://dx.doi.org/10.2169/internalmedicine.54.3870> PMID: 26179522
- Randeree IG, Czarnocki A, Moodley J, Seedat YK, Naiker IP. Acute renal failure in pregnancy in South Africa. *Ren Fail.* 1995 Mar;17(2):147–53. doi: <http://dx.doi.org/10.3109/08860229509026251> PMID: 7644765
- Bentata Y, Madani H, Berkli H, Haddiya I, Saadi H, Mimouni A, et al. Acute kidney injury according to KDIGO stages and maternal mortality in the intensive care unit. *Intensive Care Med.* 2015 Mar;41(3):555–6. doi: <http://dx.doi.org/10.1007/s00134-014-3626-8> PMID: 25567383
- Hounkponou N, Ahoui S, Obossou A, Ahouingnan A, Bankole B. Acute kidney injury epidemiological aspects in gravido-puerperal period in Parakou. *J Womens Health Care.* 2019;9(1):1000401. doi: <http://dx.doi.org/10.4172/2167-0420.1000401>
- Habib A, Abdullahi U, Muhammad A, Muhammad S, Boysunni Z. Pregnancy-related acute kidney injury in Jigawa, Nigeria. *Ann Health Res.* 2024;10(2):132–41. doi: <http://dx.doi.org/10.30442/ahr.1002-05-233>
- Shija K, Ibrahim H, Jumbe S, Lugoba B, Kibusi SM, Chandika A. Clinical presentation and treatment outcomes of pregnancy-related acute kidney injury among pregnant women admitted at the Benjamin Mkapa Hospital in Tanzania. *Open J Nephrol.* 2024;14(2):157–75. doi: <http://dx.doi.org/10.4236/ojneph.2024.142016>
- Sharma A, Kularia R, Acharya J. Study of acute kidney injury associated with pregnancy. *Int Arch BioMed Clin Res.* 2018;4(2):169–71.
- WHO Global Maternal Sepsis Study (GLOSS) Research Group. Frequency and management of maternal infection in health facilities in 52 countries (GLOSS): a 1-week inception cohort study. *Lancet Glob Health.* 2020 May;8(5):e661–71. doi: [http://dx.doi.org/10.1016/S2214-109X\(20\)30109-1](http://dx.doi.org/10.1016/S2214-109X(20)30109-1) PMID: 32353314
- Bilano VL, Ota E, Ganchimeg T, Mori R, Souza JP. Risk factors of pre-eclampsia/eclampsia and its adverse outcomes in low- and middle-income countries: a WHO secondary analysis. *PLoS One.* 2014 Mar 21;9(3):e91198. doi: <http://dx.doi.org/10.1371/journal.pone.0091198> PMID: 24657964
- Elrggal ME, Bajpai D, Tannor EK, Azmat R, Bashir AM, Banda J, et al. Access to nephrology care for pregnancy-related acute kidney injury in low-and lower-middle-income countries: a perspective. *Kidney Med.* 2023 Jul 1;5(9):100695. doi: <http://dx.doi.org/10.1016/j.xkme.2023.100695> PMID: 37602143
- Trakarnvanich T, Ngamvichchukorn T, Susantitaphong P. Incidence of acute kidney injury during pregnancy and its prognostic value for adverse clinical outcomes: A systematic review and meta-analysis. *Medicine (Baltimore).* 2022 Jul 29;101(30):e29563. doi: <http://dx.doi.org/10.1097/MD.00000000000029563> PMID: 35905231
- Tran PNT, Wannakittirat A, Luyckx V, Wiles K, Yadla M, Chakravarthi R, et al. Incidence of pregnancy-associated acute kidney injury in low- and middle-income countries: meta-analysis. Supplementary material [online repository]. London: figshare; 2025. doi: <http://dx.doi.org/10.6084/m9.figshare.29244869>
- World Bank country and lending groups [internet]. Washington, DC: World Bank; 2025. Available from: <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups> [cited 2025 May 27].
- Regional offices [internet]. Geneva: World Health Organization; 2025. Available from: <https://www.who.int/about/who-we-are/regional-offices> [cited 2025 May 27].
- World health statistics 2023: monitoring health for the SDGs, sustainable development goals. Geneva: World Health Organization; 2023. Available from: <https://www.who.int/publications/i/item/9789240074323> [cited 2025 May 27].
- Susantitaphong P, Cruz DN, Cerda J, Abulfaraj M, Alqahtani F, Koulouridis I, et al.; Acute Kidney Injury Advisory Group of the American Society of Nephrology. World incidence of AKI: a meta-analysis. *Clin J Am Soc Nephrol.* 2013 Sep;8(9):1482–93. doi: <http://dx.doi.org/10.2215/CJN.00710113> PMID: 23744003
- Maternal and newborn health coverage [internet]. New York: United Nations Children's Fund; 2025. Available from: <https://data.unicef.org/resources/dataset/maternal-newborn-health/> [cited 2024 Feb 16].
- Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. *Int J Evid-Based Healthc.* 2015 Sep;13(3):147–53. doi: <http://dx.doi.org/10.1097/XEB.0000000000000054> PMID: 26317388
- Iqbal Anvar M, Talwar S, Mallapur S. A retrospective study on clinical outcomes of pregnancy-related acute kidney injury patients at a South Indian tertiary care hospital. *Cureus.* 2023 Nov 28;15(11):e49610. doi: <http://dx.doi.org/10.7759/cureus.49610> PMID: 38161847
- Kamal S. A retrospective study on acute renal damage during pregnancy and puberty, Jharkhand, India. *SJHR-Africa.* 2024;5(3):8. doi: <http://dx.doi.org/10.51168/sjhrfrica.v5i3.1130> PMID: 38161847
- Mahalingam M, Sundarraj MT, Mohan G, Ramesh S, Kothandaraman S. Pregnancy-related acute kidney injury: our experience in a tertiary care center. *J South Asian Fed Obstet Gynecol.* 2024;16(5):583–7. doi: <http://dx.doi.org/10.5005/jp-journals-10006-2505>
- Chitale A, Shinde KK, Damle H. A study of obstetric acute renal injury. *Int J Reprod Contracept Obstet Gynecol.* 2018;7(7):2677. doi: <http://dx.doi.org/10.18203/2320-1770.ijrcog20182527>
- Prakash J, Ganiger VC, Prakash S, Iqbal M, Kar DP, Singh U, et al. Acute kidney injury in pregnancy with special reference to pregnancy-specific disorders: a hospital based study (2014-2016). *J Nephrol.* 2018 Feb;31(1):79–85. doi: <http://dx.doi.org/10.1007/s40620-017-0466-y> PMID: 29302904
- Ganesh DYS, Soujanya DB. Observational study of pregnancy related acute kidney injury in obstetrics. *IOSR J Dent Med Sci.* 2019;18(11):7–16. Available from: <https://www.iosrjournals.org/iosr-jdms/papers/Vol18-issue11/Serial-3/B1811030716.pdf> [cited 2025 Jun 6].
- Gayathiri M, Suganya SA. A study of AKI in pregnancy and puerperium. *Indian J Obstet Gynecol Res.* 2020;7(3):344–7. doi: <http://dx.doi.org/10.18231/j.ijogr.2020.074>
- Saini S, Chaudhury AR, Divyaveer S, Maurya P, Sircar D, Dasgupta S, et al. The changing face of pregnancy-related acute kidney injury from eastern part of India: A hospital-based, prospective, observational study. *Saudi J Kidney Dis Transpl.* 2020 Mar-Apr;31(2):493–502. doi: <http://dx.doi.org/10.4103/1319-2442.284025> PMID: 32394923

35. Kanmani LM, Kavya. A prospective analysis of feto-maternal outcomes in pregnancy-related acute kidney injury. *Int J Sci Res (Raipur)*. 2021;10(8):346–50. doi: <http://dx.doi.org/10.21275/MR21806192810>
36. Thakur G, Singh A, Jain V, Sikka P, Arora A, Suri V. Acute kidney injury and its outcome following maternal near-miss event: A prospective observational study from a tertiary care hospital. *Obstet Med*. 2023 Mar;16(1):48–51. doi: <http://dx.doi.org/10.1177/1753495X211069020> PMID: 37139512
37. Mandal P, Biswas S, Char D, Roy M, Chhaya S. An outcome of acute kidney injury during pregnancy: an observation and prospective study from tertiary care hospital. *J Med Appl Sci*. 2022;12(2):43. doi: <http://dx.doi.org/10.5455/jmas.43027>
38. Praba KS, Gomathi V. Study of acute kidney injury in pregnancy and postpartum period at a tertiary hospital. *Int J Acad Med Pharm*. 2022;4(5):157–60. Available from: https://academicmed.org/Uploads/Volume4Issue5/34_-52-JAMP_MEDP-157-160.pdf [cited 2025 Jun 6].
39. Sachan R, Shukla S, Shyam R, Sachan PL, Patel ML. Feto-maternal outcome of pregnancy related acute kidney injury in a North Indian population. *J Family Community Med*. 2022 Sep-Dec;29(3):204–11. doi: http://dx.doi.org/10.4103/jfcm.jfcm_117_22 PMID: 36389031
40. Anitha Y, Srilakshmi B, Penmetsa P, Penumaka RM. Renal challenges in pregnancy: investigating acute kidney failure and perinatal well-being - a prospective descriptive study. *J Clin Diagn Res*. 2023;17(11):QC10–3. doi: <http://dx.doi.org/10.7860/JCDR/2023/66474.18728>
41. Kharkongor D, Mehrotra S, Solanki V, Singh U, Patel ML, Agarwal S. Acute kidney injury in obstetrics: Hospital-based cohort study. *Trop Doct*. 2023 Jul;53(3):356–61. doi: <http://dx.doi.org/10.1177/00494755231157109> PMID: 37078137
42. Rajanna S, G Kedlaya P, Satish R, Muthugopalakrishnan G. WCN23-0948 Changing trends of pregnancy related acute kidney injury - a single centre prospective observational study from southern India. *Kidney Int Rep*. 2023;8(3):S19–20. doi: <http://dx.doi.org/10.1016/j.ekir.2023.02.044>
43. Huang C, Chen S. Acute kidney injury during pregnancy and puerperium: a retrospective study in a single center. *BMC Nephrol*. 2017 May 1;18(1):146. doi: <http://dx.doi.org/10.1186/s12882-017-0551-4> PMID: 28460634
44. Gao Y, Shui H, Hu H, Hu S, Wang R. Retrospective analysis of pregnancy-related acute kidney injury. *J Wuhan Uni*. 2018;39(3):454–8. Chinese. Available from: <https://html.rhhz.net/WHDXBYXB/html/991a1237-dd45-44ab-8976-b2847e135298.htm> [cited 2025 Jun 6].
45. Li X, Wu X, Zhang M, Xu L, Li G, Wen Y, et al. Pregnancy-related acute kidney injury at high altitude: a retrospective observational study in a single center. *BMC Nephrol*. 2021 Jun 9;22(1):215. doi: <http://dx.doi.org/10.1186/s12882-021-02418-7> PMID: 34107912
46. Li SH, Huang X, Li MX, Chu XG, Ayi-Tudi M, Li XS, et al. A seven-year retrospective study of a single center in Xinjiang: clinical features of pregnancy-related acute kidney injury. *J Clin Nephrol*. 2022;22(4):271–6. Chinese. doi: <http://dx.doi.org/10.3969/j.issn.1671-2390.2022.04.002>
47. Elshinnawy HA, Aref H, Rezk KM, Elkotb AM, Mohamed A. Study of pregnancy related AKI in Egyptian patients: incidence, risk factors and outcome. *QJM*. 2020 Mar; 113(Suppl1):hcaa052.016. doi: <http://dx.doi.org/10.1093/qjmed/hcaa052.016>
48. Gaber TZ, Shemies RS, Baiomy AA, Aladle DA, Mosbah A, Abdel-Hady ES, et al. Acute kidney injury during pregnancy and puerperium: an Egyptian hospital-based study. *J Nephrol*. 2021 Oct;34(5):1611–9. doi: <http://dx.doi.org/10.1007/s40620-021-01133-8> PMID: 34390480
49. Ismael K, Warda O, Elshamy M, Abdelhazef M. Pregnancy-related acute kidney injury: a single tertiary care center experience. *Evid Based Women's Health J*. 2024 Feb 1;14(1):32–8. doi: <http://dx.doi.org/10.21608/ebwhj.2023.243760.1266>
50. Thakur A, Basnet P, Pandey NK. Pregnancy-related acute kidney injury. *J South Asian Fed Obstet Gynecol*. 2019;11(2):90–2. doi: <http://dx.doi.org/10.5005/jp-journals-10006-1666>
51. Paudyal P, Pradhan N, Bista KDB, Rawal S. Pregnancy-related acute kidney injury at a tertiary care center in Nepal. *Nepal J Obstet Gynaecol*. 2015 Aug 17;10(1):43–7. doi: <http://dx.doi.org/10.3126/njog.v10i1.13195>
52. Waziri B, Umar IA, Magaji A, Umelo CC, Nalado AM, Wester CW, et al. Risk factors and outcomes associated with pregnancy-related acute kidney injury in a high-risk cohort of women in Nigeria. *J Nephrol*. 2024 Apr;37(3):587–96. doi: <http://dx.doi.org/10.1007/s40620-023-01822-6> PMID: 38051496
53. Ruggajo PJ, Appollo EO, Bramania PK, Basil TB, Furia FF, Mngumi JW. Prevalence, risk factors and short-term outcomes of acute kidney injury in women with obstetric complications in Dar es Salaam, Tanzania. *Tanzania Med J*. 2022;33(3). Available from: <https://www.tmj.or.tz/index.php/tmj/article/view/539> [cited 2025 Jun 6].
54. Faisal ARM, Abdullah MS, Bahar H, Mullah S, Ahmed SI, Singha AK, et al. Pregnancy-related acute kidney injury: a multicenter prospective observational study from Bangladesh. *J Dhaka Med Coll*. 2023;30(1):76–81. doi: <http://dx.doi.org/10.3329/jdmc.v30i1.56906>
55. Abderraman GM, Charfadine S, Hissein A. Outcome of acute kidney injury in pregnancy in N'Djamena, Chad. *Open J Nephrol*. 2023;13(4):369–77. doi: <http://dx.doi.org/10.4236/ojneph.2023.134034>
56. Berhe E, Tekla H, Abraha HE, Abera BT, Gebru MA, Gebremariam T, et al. Characteristics and outcome of pregnancy-related acute kidney injury in a teaching hospital in a low-resource setting: a five-year retrospective review. *BMC Nephrol*. 2024 May 22;25(1):182. doi: <http://dx.doi.org/10.1186/s12882-024-03616-9> PMID: 38778267
57. Bah IK, Diakite F, Baldé MS, Diallo A, Bah MY, Diallo AY, et al. Obstetrical acute kidney injury: epidemiology and clinical aspects in teaching hospital of Ignace Deen, Conakry Guinea. *Case Rep Clin Med*. 2020;9(1):35–9. doi: <http://dx.doi.org/10.4236/crcm.2020.91006>
58. Kivai J, Kayima JK, Were AJO, Zahida Q. Impact of pregnancy-related acute kidney injury on foetal survival: a single centre experience in Kenya. *IOSR J Dent Med Sci*. 2019;18(7):13–7. Available from: https://www.academia.edu/94901156/Impact_of_Pregnancy_Related_Acute_Kidney_Injury_on_foetalsurvival_a_single_Centre_Experience_in_Kenya [cited 2025 Jun 6].
59. Cooke WR, Hemmilla UK, Craik AL, Mandula CJ, Mvula P, Msusa A, et al. Incidence, aetiology and outcomes of obstetric-related acute kidney injury in Malawi: a prospective observational study. *BMC Nephrol*. 2018 Feb 2;19(1):25. doi: <http://dx.doi.org/10.1186/s12882-018-0824-6> PMID: 29394890
60. Reston KND, Ti CRA. Prevalence and clinical profile of patients with pregnancy-related acute kidney injury: a single-center retrospective study. *Philippine J Int Med*. 2024;62(4):183–9. Available from: <http://wprim.whocc.org.cn/admin/articleDetail?WPRIMID=1063359&articleId=1098313> [cited 2025 Jun 5].
61. Meca D-C, Vasilescu S, Mehedințu C, Cîrstoiu MM. The impact of dialysis on clinical and paraclinical parameters in acute renal failure associated with pregnancy or postpartum period. *Obstet Ginecol (Bucur)*. 2021;69(4):162–5. doi: <http://dx.doi.org/10.26416/ObsGin.69.4.2021.5768>
62. Rage HI, Kumar Jha P, Hashi HA, Abdillahi NI. Pregnancy-Related AKI: A Tertiary Care Hospital Experience in Somaliland. *Kidney Int Rep*. 2023 Jan 25;8(3):388–91. doi: <http://dx.doi.org/10.1016/j.ekir.2023.01.021> PMID: 36938070
63. Sedgh G, Singh S, Hussain R. Intended and unintended pregnancies worldwide in 2012 and recent trends. *Stud Fam Plann*. 2014 Sep;45(3):301–14. doi: <http://dx.doi.org/10.1111/j.1728-4465.2014.00393.x> PMID: 25207494
64. Shalaby AS, Shemies RS. Pregnancy-related acute kidney injury in the African continent: where do we stand? A systematic review. *J Nephrol*. 2022 Dec;35(9):2175–89. doi: <http://dx.doi.org/10.1007/s40620-022-01349-2> PMID: 35708883
65. Trends in maternal mortality 2000 to 2020: estimates by WHO, UNICEF, UNFPA, World Bank Group and UNDESA/Population Division. Geneva: World Health Organization; 2023. Available from: <https://www.who.int/publications/i/item/9789240068759> [cited 2025 May 27].
66. Bello AK, Okpechi IG, Levin A, Ye F, Saad S, Zaidi D, et al. ISN–Global Kidney Health Atlas. Brussels: International Society of Nephrology; 2023. Available from: https://www.theisn.org/wp-content/uploads/media/ISN%20Atlas_2023%20Digital.pdf [cited 2025 May 27].
67. Cresswell JA, Alexander M, Chong MYC, Link HM, Pejchinovska M, Gazeley U, et al. Global and regional causes of maternal deaths 2009–20: a WHO systematic analysis. *Lancet Glob Health*. 2025 Apr;13(4):e626–34. doi: [http://dx.doi.org/10.1016/S2214-109X\(24\)00560-6](http://dx.doi.org/10.1016/S2214-109X(24)00560-6) PMID: 40064189
68. Karimi Z, Malekmakan L, Farshadi M. The prevalence of pregnancy-related acute renal failure in Asia: a systematic review. *Saudi J Kidney Dis Transpl*. 2017 Jan-Feb;28(1):1–8. doi: <http://dx.doi.org/10.4103/1319-2442.198092> PMID: 28098096

69. WHO recommendations for prevention and treatment of pre-eclampsia and eclampsia. Geneva: World Health Organization; 2011. Available from: <https://www.who.int/publications/i/item/9789241548335> [cited 2025 May 27].
70. Bridwell RE, Carius BM, Long B, Oliver JJ, Schmitz G. Sepsis in pregnancy: recognition and resuscitation. *West J Emerg Med*. 2019 Aug 6;20(5):822–32. doi: <http://dx.doi.org/10.5811/westjem.2019.6.43369> PMID: 31539341
71. Omotayo MO, Abioye AI, Kuyebi M, Eke AC. Prenatal anemia and postpartum hemorrhage risk: a systematic review and meta-analysis. *J Obstet Gynaecol Res*. 2021 Aug;47(8):2565–76. doi: <http://dx.doi.org/10.1111/jog.14834> PMID: 34002432
72. Banerjee A, Mehrotra G. Comparison of standard conservative treatment and early initiation of renal replacement therapy in pregnancy-related acute kidney injury: a single-center prospective study. *Indian J Crit Care Med*. 2020 Aug;24(8):688–94. doi: <http://dx.doi.org/10.5005/jp-journals-10071-23537> PMID: 33024376
73. Amponsah-Tabi S, Dassah ET, Asubonteng GO, Ankobea F, Annan JJK, Senu E, et al. An assessment of the quality of antenatal care and pregnancy outcomes in a tertiary hospital in Ghana. *PLoS One*. 2022 Oct 12;17(10):e0275933. doi: <http://dx.doi.org/10.1371/journal.pone.0275933> PMID: 36223426