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Systematic Review Article

Risk factors for Pregnancy induced Hypertension: Systematic Review

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Abstract:

This systematic review synthesized current evidence on risk factors associated with pregnancy-induced hypertension (PIH) and pre-eclampsia. A comprehensive literature search for hypertensive disorders of pregnancy (HDP) across PubMed, Scopus, Web of Science, and Embase identified 874 studies, of which 18 met inclusion criteria based on PRISMA guidelines. Eligible studies comprised systematic reviews and cohort studies evaluating predictors of HDP. Across studies, advanced maternal age, primiparity, obesity, pre-existing hypertension, diabetes, and family history of hypertension were consistent risk factors. Low education, poor nutrition, and inadequate antenatal care further increased risk, especially in resource-limited settings. Early pregnancy mean arterial pressure and prehypertension were strong predictors of later HDP. Systematic reviews emphasized the role of pre-pregnancy cardiovascular health, lifestyle, and occupational exposures in determining HDP risk. Given the heterogeneity of study designs and outcomes, findings were narratively synthesized. The evidence highlights the multifactorial nature of HDP and the need for early risk assessment and preventive strategies in antenatal care.

Keywords: Pregnancy-Induced Hypertension, Hypertensive Disorders Of Pregnancy, Pre-Eclampsia, Risk Factors, Predictors, Systematic Review.

Introduction

Hypertensive disorders of pregnancy (HDP), which include gestational hypertension and pre-eclampsia, remain important contributors to maternal and perinatal morbidity worldwide and arise from a complex interplay of maternal, obstetric, metabolic and environmental factors. Early systematic syntheses of observational studies identified several consistent antenatal predictors — including nulliparity, prior pre-eclampsia, chronic hypertension, obesity, diabetes, and multifetal gestation — that increase the risk of pre-eclampsia. [1] Subsequent large cohort meta-analyses refined this evidence base and quantified the prognostic importance of routinely available clinical variables (for example maternal age, body mass index and pre-existing hypertension), supporting their use in early pregnancy risk stratification. [2]

Given the multifactorial etiology of HDP, multiple prediction models and variable sets have been proposed; systematic reviews of these models indicate that maternal characteristics (BMI, blood pressure, parity and medical history) are the most frequently used predictors, although model discrimination and external validity remain heterogeneous. [3] Recent evidence further underscores the contribution of pre-pregnancy cardiometabolic health (including obesity, hypertension and diabetes) to HDP risk, and highlights context-specific determinants from low- and middle-income settings. [4,5] Contemporary cohort studies continue to report consistent associations of higher pre-pregnancy BMI, advanced maternal age and elevated early-pregnancy mean arterial pressure with new-onset HDP, reinforcing the need for early identification of high-risk women. [6] Importantly, emerging population-based data also link maternal HDP to adverse long-term cardiovascular outcomes in offspring, suggesting intergenerational consequences and strengthening the public-health imperative for preventive strategies. [7] In this context, a focused qualitative synthesis of recent systematic reviews and high-quality cohort studies is needed to consolidate current evidence on risk factors for pregnancy-induced hypertension and inform screening and prevention priorities.

Material and Methods

Study Design and Protocol: This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [8]. The review aimed to identify, synthesize, and summarize the existing evidence on risk factors and predictors associated with PIH. The review protocol was designed a priori, and the eligibility criteria, data extraction framework, and synthesis approach were predefined.

Search Strategy: A comprehensive literature search was performed across major electronic databases—PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar—for studies published between January 2005 and September 2025. The following combination of Medical Subject Headings (MeSH) and free-text terms were used: "pregnancy-induced hypertension" OR "gestational hypertension" OR "hypertensive disorders of pregnancy" OR "pre-eclampsia" AND "risk factors" OR "predictors" OR "determinants" OR "etiology" AND "systematic review" OR "cohort study" OR "case-control study". Reference lists of relevant articles and reviews were also manually searched to identify additional eligible studies.

Eligibility Criteria: Studies were included if they investigated pregnant women diagnosed with pregnancy-induced hypertension, gestational hypertension, or pre-eclampsia. Eligible study designs comprised systematic reviews, prospective or retrospective cohort studies, case-control studies, and population-based cross-sectional analyses. Only studies that identified or evaluated risk factors or predictors associated with the development or progression of pregnancy-induced hypertension or other hypertensive disorders of pregnancy were considered. Publications were restricted to the English language. Studies were excluded if they were case reports, animal studies, editorials, or letters to the editor, or if they focused exclusively on management strategies or treatment outcomes rather than risk assessment.

Study Selection: Two independent reviewers screened all retrieved titles and abstracts. Full texts of potentially eligible studies were evaluated for inclusion based on predefined criteria. Discrepancies were resolved by discussion and, if necessary, consultation with a third reviewer. The study selection process was documented using the PRISMA 2020 flow diagram. Out of all retrieved records, 18 studies met the inclusion criteria and were incorporated into the qualitative synthesis.

Study Screening Process: A comprehensive literature search initially identified 874 records through database searching (PubMed, Scopus, Web of Science, and Embase). After removing 312 duplicates, 562 records remained for title and abstract screening. Of these, 472 records were excluded for irrelevance or not meeting inclusion criteria. The full texts of 90 articles were assessed for eligibility. Following detailed review, 72 studies were excluded due to insufficient data on risk factors, non-original research (reviews, letters, or editorials), or focus on treatment rather than risk prediction. Finally, 18 studies met the eligibility criteria and were included in the qualitative synthesis.

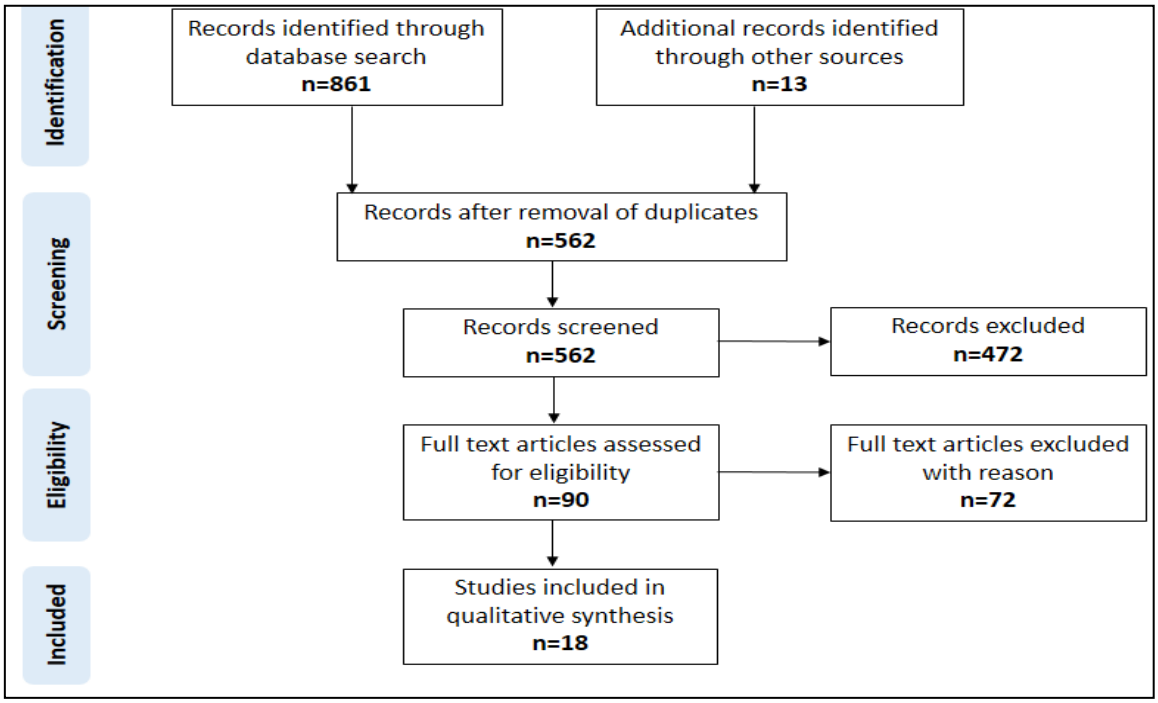

Figure 1: PRISMA flow diagram

Data Extraction and Management: A standardized data extraction form was used to record essential study details, including author name, publication year, country, study design, sample size, population characteristics, outcome measures, and main risk factors identified. Data extraction was performed independently by two reviewers to minimize bias and cross-checked for accuracy.

Quality Assessment: The methodological quality and risk of bias of the included studies were assessed using appropriate tools depending on study design. For cohort and case-control studies, the Newcastle–Ottawa Scale (NOS) [9] was used, whereas systematic reviews were evaluated using the AMSTAR-2 tool [10]. Studies were categorized as low, moderate, or high quality based on the respective scoring systems.

Data Synthesis: Due to heterogeneity among the included studies in terms of design, outcome definitions, and effect measures, a meta-analysis was not feasible. Therefore, a qualitative synthesis of the findings was performed. The included studies were organized into three thematic categories: population-based and prospective cohort studies, maternal and pregnancy-related predictors, and systematic reviews or meta-analyses. Results from each category were synthesized narratively and displayed in tabular format, emphasizing the most consistent and significant risk factors reported across studies.

Results

Table 1: Prospective and Population-based Cohort Studies on HDP and Outcomes

Citation / Study Design	Outcome(s) Examined	Main Risk Factors / Predictors Identified
Pembe AB et al., 2025 – Prospective Cohort (India & Tanzania) [5]	HDP and perinatal outcomes	Low education, undernutrition, primiparity, young maternal age increased risk; linked to stillbirth and LBW.
Nakimuli A et al., 2025 – Prospective Cohort (Africa) [11]	Progression from pre-eclampsia to eclampsia	Poor antenatal follow-up, severe hypertension, and delayed treatment predicted progression.
Chen Y et al., 2025 – Population-based Study (China) [12]	Incidence and determinants of HDP	Increasing age, obesity, diabetes, prior cesarean, and socioeconomic factors.
Hayati TV et al., 2024 – Cross-sectional / Cohort Study [134]	Gestational hypertension	BMI > 25, primigravidity, family history of hypertension, and anemia associated with HDP.
Dines VA et al., 2023 – Population-based Study (USA) [7]	Offspring hypertension after maternal HDP	Offspring from hypertensive pregnancies had higher adult hypertension risk.

Table 2. Cohort Studies Assessing Maternal and Pregnancy-related Risk Factors

Citation / Study Design	Outcome(s) Examined	Main Risk Factors / Predictors Identified
Zhou L et al., 2024 – Retrospective Cohort Study [6]	New-onset HDP	Pre-pregnancy BMI > 25, age > 35 years, family history, elevated MAP in early pregnancy.
Nie X et al., 2024 – Retrospective Cohort (Chronic HTN) [14]	Preeclampsia among chronic hypertensive women	Older age, obesity, long-standing hypertension increased risk of superimposed pre-eclampsia.
Perejón D et al., 2024 – Retrospective Population-based Cohort [15]	Hypertension subtypes and outcomes	Chronic and gestational hypertension led to higher rates of IUGR, preterm birth, cesarean delivery.
Nagao T et al., 2021 – Historical Cohort (Japan) [16]	Hypertensive disorders in pregnancy	Early pregnancy prehypertension (SBP ≥ 120 mmHg or DBP ≥ 80 mmHg) predicted later HDP.
Muto H et al., 2016 – Single-center Cohort (Japan) [17]	Hypertensive disorders	Advanced age ≥ 40, obesity ≥ 30 kg/m², IVF conception, elevated early BP.

Table 3: Systematic Reviews on Risk Factors for Pregnancy-Induced Hypertension

Citation / Study Design	Outcome(s) Examined	Main Risk Factors / Predictors Identified (Summary)
Rodriguez-Caro H et al., 2025 – Systematic Review & Meta-analysis [4]	Pre-pregnancy health and HDP	Pre-pregnancy obesity, diabetes, hypertension, and suboptimal cardiovascular health.
Spadarella E et al., 2021 – Systematic Review (Occupational Risks) [18]	Hypertensive disorders in pregnancy	Long working hours, shift work, noise exposure, chemical stressors linked to higher HDP risk.
Antwi E et al., 2020 – Systematic Review (Prediction Models) [19]	Gestational hypertension and pre-eclampsia	Maternal BMI, blood pressure, parity, prior pre-eclampsia most common predictors.
De Kat AC et al., 2019 – Systematic Review (Prediction Models) [3]	Prediction models for pre-eclampsia	Maternal age, BMI, parity, previous pre-eclampsia, mean arterial pressure, biomarkers (PlGF, sFlt-1).
Bartsch E et al., 2016 – Systematic Review & Meta-analysis (Large Cohorts) [2]	Pre-eclampsia	High BMI, chronic hypertension, diabetes, renal and autoimmune disease, multiple gestation, advanced maternal age.
Thilagnathan B, 2016 – Critical Review [20]	Methodological limitations	Highlighted inconsistency in definitions, design, and data quality across reviews.
Dodd JM et al., 2014 – Systematic Review [21]	Dietary factors in pre-eclampsia	Low calcium and vitamin D intake, poor diet quality increased risk; healthy diet protective.
Duckitt K et al., 2005 – Systematic Review (Controlled Studies) [1]	Pre-eclampsia	Nulliparity, previous pre-eclampsia, family history, obesity, diabetes, chronic hypertension, and multifetal gestation increased risk.

Across multicentric and population-based cohort studies, several consistent determinants of hypertensive disorders of pregnancy (HDP) were identified (Table 1). Maternal factors such as low educational status, undernutrition, primiparity, and young maternal age were strongly associated with increased HDP risk, leading to adverse perinatal outcomes including stillbirth and low birth weight [5]. Poor antenatal attendance and delayed management predicted progression from pre-eclampsia to eclampsia in African cohorts [11]. Population-based data from China and the USA further underscored the roles of obesity, diabetes, advanced maternal age, and prior cesarean delivery as major risk factors, with long-term implications for offspring hypertension [7, 12]. Collectively, these studies highlight the multifactorial nature of HDP, influenced by maternal demographics, comorbidities, and perinatal care quality.

Evidence from retrospective and historical cohort studies (Table 2) consistently demonstrated the contribution of maternal metabolic and obstetric characteristics to HDP development. High pre-pregnancy BMI, advanced age, and family history of hypertension were recurrently identified as key predictors [6,17]. Among women with chronic hypertension, prolonged disease duration and obesity increased the likelihood of superimposed pre-eclampsia [14]. Studies also revealed that even mildly elevated blood pressure in early gestation predisposed women to subsequent HDP [16], while hypertension subtypes were associated with higher rates of intrauterine growth restriction, preterm birth, and cesarean section [15]. These findings reinforce the importance of early antenatal screening and management of modifiable maternal factors to mitigate HDP risk.

Comprehensive reviews have consolidated the understanding of HDP risk determinants (Table 3). Maternal obesity, pre-existing hypertension, diabetes, and poor cardiovascular health emerged as the strongest predictors of PIH and pre-eclampsia across populations [2,4]. Occupational and environmental exposures such as shift work, noise, and chemical stressors were also linked to elevated HDP risk [18]. Prediction model reviews consistently identified maternal age, BMI, parity, prior pre-eclampsia, and biomarkers like PlGF and sFlt-1 as reliable predictors [3,16]. Dietary reviews highlighted that adequate calcium and vitamin D intake and overall healthy diet may confer protection [21]. Methodological appraisals noted heterogeneity in definitions and model performance across studies [20]. Collectively, these systematic syntheses emphasize the interplay of biological, behavioral, and environmental factors underlying HDP pathogenesis.

Discussion

In this qualitative synthesis of recent systematic reviews and cohort studies, maternal cardiometabolic health, early pregnancy blood pressure and body mass index, and sociodemographic disadvantage emerged as the most consistent and clinically actionable determinants of HDP. These findings align with

contemporary interventional and observational evidence: randomized data show that risk-directed preventive measures such as low-dose aspirin reduce the incidence of preterm pre-eclampsia among high-risk women, validating early risk stratification based on maternal history and clinical variables. [22–24] Our synthesis extends this by showing that, beyond classical obstetric predictors, population-level determinants including undernutrition, low education, and limited antenatal care substantially modify risk in low-resource settings and contribute to adverse perinatal outcomes. [25,26]

Mechanistically, the observed associations of obesity, diabetes and elevated early-pregnancy mean arterial pressure with incident HDP are biologically plausible and supported by current pathophysiologic models implicating abnormal placentation, systemic endothelial dysfunction and heightened maternal inflammatory/oxidative stress. Biomarker research (notably the sFlt-1/PlGF axis) offers objective measures that reflect these pathways and can complement clinical prediction, but reviews document variable predictive performance and emphasize that biomarkers currently improve short-term prediction most reliably when used in combination with clinical data [27–29]. Prediction-modelling literature also highlights a frequent reliance on routinely measured maternal characteristics (age, parity, BMI, baseline BP) and a persistent gap in external validation and generalizability across populations, which supports our decision to synthesize evidence qualitatively rather than pool effect sizes [30].

From a policy and clinical-practice perspective, guideline statements recommend integrating clinical risk factors with targeted preventive strategies and monitoring; however, heterogeneity in guideline thresholds and in recommended aspirin dosing reflects ongoing uncertainties about optimal implementation—particularly across diverse resource settings [31]. The long-term implications of HDP reinforce the public-health importance of detection and prevention: women with a pregnancy complicated by HDP face substantially higher risks of subsequent chronic hypertension and cardiovascular disease, underscoring the opportunity for postpartum cardiovascular risk reduction and life-course interventions [32,33].

Strengths of this review include a focused, up-to-date synthesis that integrates diverse study designs and emphasizes context-specific determinants relevant to both high-income and low-resource settings. Several limitations deserve mention. First, heterogeneity in outcome definitions (gestational hypertension versus pre-eclampsia) and in timing/thresholds for early BP measurements limited direct comparability across studies. Second, although biomarkers and prediction models show promise, the evidence base remains unevenly distributed geographically and often lacks robust external validation, reducing immediate generalizability. Third, the exclusion of non-English reports and potential publication bias in primary literature may have omitted relevant regional data.

Conclusion

The available evidence supports early antenatal assessment of maternal cardiometabolic status (BMI, baseline BP, diabetes, prior HDP) combined with attention to social determinants to identify women at elevated risk of PIH and HDP. Risk-based prevention (for example, prophylactic aspirin) and strengthened antenatal care in underserved populations are practical priorities supported by current evidence, while further research should focus on externally validated prediction tools, the integration of biomarker panels into clinical practice, and implementation studies to define optimal prevention strategies across settings.

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