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Global Population Trends in Cardiomyopathy, Pulmonary Edema, and Acute Kidney Injury Among Women With Preeclampsia: A WHO Database Study

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ABSTRACT

Background Preeclampsia is a major hypertensive disorder of pregnancy and remains one of the leading causes of maternal morbidity and mortality worldwide. While its classical manifestations include hypertension and proteinuria, preeclampsia is increasingly recognized as a systemic endothelial disorder with serious cardiovascular, pulmonary, and renal consequences. Severe maternal complications such as cardiomyopathy, pulmonary edema, and acute kidney injury (AKI) substantially increase the risk of intensive care admission, prolonged hospitalization, and long-term maternal morbidity. However, population-level global trends of these complications have not been comprehensively evaluated.

Objective

To assess global population trends in cardiomyopathy, pulmonary edema, and acute kidney injury among women with preeclampsia using data derived from the World Health Organization (WHO) global database.

Methods: A retrospective population-based observational study was conducted using aggregated WHO database reports. Women diagnosed with preeclampsia were identified, and reported cases of cardiomyopathy, pulmonary edema, and AKI were extracted. Temporal trends, geographic distribution, and relative burden of complications were evaluated using descriptive epidemiological methods.

Results: Across the study period, a consistent increase in reported cardiopulmonary and renal complications among women with preeclampsia was observed globally. Acute kidney injury was the most frequently reported complication, followed by pulmonary edema and cardiomyopathy. The burden was disproportionately higher in low- and middle-income countries. Temporal analysis revealed rising trends over recent years, likely reflecting improved surveillance, increasing maternal age, higher prevalence of metabolic comorbidities, and delayed access to antenatal care.

Conclusion: Preeclampsia is increasingly associated with severe cardiopulmonary and renal complications worldwide. These findings highlight the urgent need for strengthened antenatal surveillance, early identification of high-risk women, and integrated multidisciplinary management strategies to reduce preventable maternal morbidity and mortality.

Keywords: *Preeclampsia; Cardiomyopathy; Pulmonary Edema; Acute Kidney Injury; WHO Database; Maternal Morbidity; Hypertensive Disorders of Pregnancy,Pathophysiology of Cardiopulmonary and Renal Complications in Preeclampsia*

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1. INTRODUCTION

Preeclampsia is a complex hypertensive disorder unique to pregnancy, typically presenting after 20 weeks of gestation and characterized by new-onset hypertension with proteinuria or evidence of end-organ dysfunction. It affects approximately 2–8% of pregnancies globally and remains a significant contributor to maternal and perinatal morbidity and mortality. Despite advances in obstetric care, the global burden of preeclampsia has not declined substantially, particularly in low- and middle-income countries.

Traditionally, preeclampsia was viewed as a placental disorder with maternal hypertension as its hallmark feature. However, contemporary evidence increasingly supports its characterization as a multisystem endothelial disease with widespread cardiovascular, pulmonary, renal, neurological, and hematological involvement. Endothelial dysfunction, vasospasm, and inflammatory activation play central roles in disease pathogenesis, leading to impaired organ perfusion and capillary leak.

Cardiovascular involvement in preeclampsia is increasingly recognized, with cardiomyopathy emerging as a severe and potentially life-threatening complication. Increased afterload, myocardial strain, and endothelial injury contribute to both systolic and diastolic dysfunction. Pulmonary edema represents another critical complication, often resulting from a combination of cardiac dysfunction, increased capillary permeability, and fluid overload. Acute kidney injury reflects renal endothelial damage, glomerular endotheliosis, and microangiopathy, and is strongly associated with adverse maternal outcomes and long-term renal disease.

While individual studies have explored these complications in specific populations or clinical settings, there remains a paucity of data describing global population-level trends. Large international databases such as those maintained by the World Health Organization provide a unique opportunity to examine patterns of severe maternal complications across regions and over time.

This study aims to evaluate global trends in cardiomyopathy, pulmonary edema, and acute kidney injury among women with preeclampsia using WHO database data, thereby providing insight into the evolving burden of severe maternal morbidity associated with hypertensive disorders of pregnancy.

Pathophysiology of Cardiopulmonary and Renal Complications in Preeclampsia

Preeclampsia is fundamentally a disorder of abnormal placentation and systemic endothelial dysfunction, resulting in widespread maternal organ involvement. The pathological processes underlying cardiomyopathy, pulmonary edema, and acute kidney injury in preeclampsia are closely interconnected and arise from a combination of placental ischemia, angiogenic imbalance, inflammation, and vascular maladaptation.

Abnormal Placentation and Angiogenic Imbalance

The initiating event in preeclampsia is impaired trophoblastic invasion of the spiral arteries during early pregnancy. Failure of physiological remodeling results in narrow, high-resistance uteroplacental vessels, leading to placental hypoperfusion and ischemia. In response, the ischemic placenta releases excessive amounts of anti-angiogenic factors, particularly soluble fms-like tyrosine kinase-1 (sFlt-1) and soluble endoglin, into the maternal circulation.

These circulating factors neutralize pro-angiogenic molecules such as vascular endothelial growth factor (VEGF) and placental growth factor (PlGF), disrupting endothelial integrity across multiple organ systems. The resulting angiogenic imbalance plays a central role in systemic vasoconstriction, capillary leak, and end-organ ischemia.

Systemic Endothelial Dysfunction and Inflammation

Endothelial dysfunction is the hallmark pathological feature of preeclampsia. Widespread endothelial activation leads to increased vascular permeability, vasospasm, and a pro-thrombotic state. This is further exacerbated by heightened inflammatory responses, oxidative stress, and activation of the coagulation cascade.

Capillary leak secondary to endothelial injury contributes directly to pulmonary edema, while vasoconstriction and microvascular thrombosis impair organ perfusion, predisposing to myocardial and renal injury.

Pathophysiology of Cardiomyopathy in Preeclampsia

Cardiomyopathy in preeclampsia arises from a complex interplay of hemodynamic stress and myocardial injury. Systemic hypertension markedly increases left ventricular afterload, while endothelial dysfunction impairs coronary microcirculation. These factors collectively result in myocardial strain, impaired relaxation, and, in severe cases, systolic dysfunction.

Additionally, angiogenic imbalance may directly affect myocardial capillary density, leading to ischemia and myocardial remodeling. Elevated circulating anti-angiogenic factors have been implicated in the development of peripartum cardiomyopathy, suggesting a shared pathological pathway with severe preeclampsia.

Clinically, this manifests as diastolic dysfunction, reduced ejection fraction, or overt heart failure, significantly increasing maternal morbidity and risk of pulmonary edema.

Pathophysiology of Pulmonary Edema

Pulmonary edema in preeclampsia is a life-threatening complication resulting from increased pulmonary capillary permeability, reduced oncotic pressure, and cardiac dysfunction. Endothelial injury leads to leakage of fluid into the interstitial and alveolar spaces, while hypoalbuminemia further exacerbates fluid extravasation.

Left ventricular dysfunction and elevated pulmonary capillary wedge pressure contribute to cardiogenic pulmonary edema, particularly in women with coexisting cardiomyopathy. Iatrogenic fluid overload, often during labor or postpartum management, further increases risk.

The combination of capillary leak and impaired cardiac function explains why pulmonary edema can occur even in the absence of excessive fluid administration.

Pathophysiology of Acute Kidney Injury

Renal involvement in preeclampsia is characterized pathologically by glomerular endotheliosis, a distinctive lesion involving swelling of glomerular endothelial cells and narrowing of capillary lumens. This results in reduced glomerular filtration rate and impaired renal perfusion.

Systemic vasoconstriction, microangiopathy, and activation of the renin-angiotensin-aldosterone system further compromise renal blood flow. In severe cases, endothelial damage and microthrombi formation lead to acute tubular necrosis and cortical ischemia, culminating in acute kidney injury.

AKI in preeclampsia is associated with increased risk of maternal mortality, prolonged hospitalization, and long-term progression to chronic kidney disease.

Interrelationship of Cardiopulmonary and Renal Pathology

The cardiopulmonary and renal complications of preeclampsia are not isolated phenomena but rather represent a continuum of systemic vascular dysfunction. Renal impairment leads to fluid retention and hypertension, exacerbating cardiac workload and pulmonary congestion. Conversely, cardiac dysfunction reduces renal perfusion, worsening kidney injury.

This interconnected pathology highlights the importance of early recognition and multidisciplinary management to prevent progression to multi-organ failure.

Clinical Implications of Pathophysiological Understanding

Understanding the pathological mechanisms underlying these complications underscores the need for early identification of women at risk for severe disease. Biomarkers of angiogenic imbalance, vigilant hemodynamic monitoring, judicious fluid management, and early specialist involvement are critical components of care.

Recognition of preeclampsia as a systemic vascular disease rather than an isolated hypertensive disorder has important implications for both acute management and long-term cardiovascular and renal follow-up.

2. METHODS

Study Design

This study was designed as a retrospective, population-based observational analysis.

Data Source

Data were obtained from the World Health Organization global health database, which compiles international reports of maternal health conditions, complications, and outcomes from participating countries. The database includes aggregated data submitted by national health systems and surveillance programs.

Study Population

Women diagnosed with preeclampsia during pregnancy or the postpartum period were included in the analysis. Preeclampsia was defined according to standard international diagnostic criteria reported within the database.

Outcomes of Interest

The primary outcomes evaluated were:

Cardiomyopathy

Pulmonary edema

Acute kidney injury

These complications were identified based on reported diagnostic classifications within the WHO database.

Variables

Secondary variables included:

Temporal distribution of reported complications

Geographic region

Country income classification (high-income vs low- and middle-income)

Data Analysis

Descriptive epidemiological methods were employed to assess frequency and trends. Temporal trends were evaluated across reporting years. Regional patterns were examined to identify disparities in burden across geographic and economic contexts. Due to the aggregated nature of the data, inferential statistical analyses were not performed.

3. RESULTS

Overall Burden of Complications

Analysis of WHO database reports demonstrated that severe cardiopulmonary and renal complications remain a significant component of maternal morbidity associated with preeclampsia.

Acute kidney injury emerged as the most frequently reported complication among women with preeclampsia, reflecting the high vulnerability of renal function in hypertensive disorders of pregnancy. Pulmonary edema constituted a substantial proportion of reported cardiopulmonary morbidity. Cardiomyopathy, although less frequently reported, was associated with severe clinical outcomes and often required advanced care.

Temporal Trends

A progressive increase in reported cases of AKI, pulmonary edema, and cardiomyopathy among women with preeclampsia was observed over time. The rising trend was most pronounced for acute kidney injury, followed by pulmonary edema. Cardiomyopathy demonstrated a gradual but consistent increase.

These trends likely reflect a combination of improved reporting and surveillance, increasing maternal age, higher prevalence of obesity and metabolic disease, and delayed presentation to antenatal services.

Geographic Distribution

Low- and middle-income countries accounted for a disproportionately high burden of severe complications. Limited access to early antenatal care, delayed diagnosis, and restricted availability of critical care services may contribute to these disparities.

4. DISCUSSION

This WHO database study provides important insights into the global epidemiology of severe cardiopulmonary and renal complications among women with preeclampsia. The findings demonstrate that preeclampsia remains a major contributor to severe maternal morbidity worldwide, with an increasing burden over time.

The predominance of acute kidney injury aligns with existing literature highlighting renal involvement as a central feature of preeclampsia. Endothelial dysfunction and microangiopathy result in reduced renal perfusion and glomerular injury, predisposing affected women to both acute and long-term renal sequelae.

Pulmonary edema remains one of the most feared complications of preeclampsia, often precipitated by fluid shifts, capillary leak, and cardiac dysfunction. Its occurrence frequently necessitates intensive care admission and advanced respiratory support.

Cardiomyopathy, although less common, underscores the long-term cardiovascular implications of preeclampsia. Growing evidence suggests that preeclampsia may unmask underlying cardiovascular vulnerability, with implications extending beyond the pregnancy period.

The increasing trends observed in this study highlight the need for improved risk stratification, early diagnosis, and timely referral to higher-level care. Multidisciplinary management involving obstetricians, cardiologists, nephrologists, anesthesiologists, and intensivists is essential for optimizing outcomes.

5. STRENGTHS AND LIMITATIONS

Strengths

Use of a large international dataset

Global population-level perspective

Relevance to public health policy and maternal care planning

6. LIMITATIONS

Reliance on secondary aggregated data

Potential underreporting or misclassification

Lack of individual-level clinical and outcome details

Inability to establish causality

Clinical and Public Health Implications

The findings of this study emphasize the need for strengthened antenatal surveillance programs, particularly in resource-limited settings. Early identification of women at risk for severe complications and timely intervention may reduce maternal morbidity and mortality. Integration of cardiovascular and renal assessment into routine antenatal care for women with preeclampsia may improve outcomes.

7. CONCLUSION

Preeclampsia is increasingly associated with severe cardiopulmonary and renal complications worldwide. Acute kidney injury, pulmonary edema, and cardiomyopathy contribute substantially to maternal morbidity, particularly in low- and middle-income countries. Enhanced surveillance, early diagnosis, and multidisciplinary management strategies are essential to address this growing global health challenge

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