ORIGINAL RESEARCH PAPER
Volume - 15 | Issue - 07 | July - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

MICROALBUMINURIA IN EARLY PREGNANCY AS A PREDICTOR OF PREECLAMPSIA – AN OBSERVATIONAL PROSPECTIVE STUDY

Obstetrics & Gynaecology

Dr. Shreya Shree — Resident, Department of Obstetrics and Gynaecology, A.J. Institute of Medical Sciences and Research Centre, Kuntikhana, Mangalore - 562114, Karnataka, India

Dr. Mamatha. M. L — Resident, Department of Obstetrics and Gynaecology, A.J. Institute of Medical Sciences and Research Centre, Kuntikhana, Mangalore - 562114, Karnataka, India

Dr. Kavitha D'Souza — Professor, Department of Obstetrics and Gynaecology, A.J. Institute of Medical Sciences and Research Centre, Kuntikhana, Mangalore - 562114, Karnataka, India

Dr. Pradeep Ganiga — Professor and HOD, Department of Obstetrics and Gynaecology, A.J. Institute of Medical Sciences and Research Centre, Kuntikhana, Mangalore - 562114, Karnataka, India

ABSTRACT

Introduction: Preeclampsia is a multisystem disorder that can lead to maternal and fetal morbidity and mortality due to complications such as eclampsia, preterm birth, fetal growth restriction, and organ dysfunction. Microalbuminuria has been proposed as an early marker of endothelial dysfunction, which plays a critical role in the pathogenesis of preeclampsia. The detection of microalbuminuria in early pregnancy (11–26 weeks gestation) could serve as an early screening tool for preeclampsia, allowing for timely intervention and better maternal and fetal outcomes. Given the high burden of preeclampsia-related complications worldwide, identifying biomarkers for early prediction remains a research priority. **Aim of the study:** 1. To assess the levels of microalbuminuria in early pregnancy (11–26 weeks gestation). 2. To determine its predictive value for preeclampsia and evaluate its correlation with maternal and fetal outcomes. This study will provide scientific evidence for incorporating microalbuminuria screening into routine antenatal care, potentially improving early risk stratification and management strategies for preeclampsia. **Methodology:** A prospective observational study was conducted involving 100 singleton pregnancies at AJIMS and attached hospitals. Convenience sampling was utilized to select 100 cases. Data on maternal demographics, antenatal risk factors, intrapartum parameters, and neonatal outcomes were collected. Analysis involved SPSS version 25, using chi-square tests and logistic regression, with statistical significance defined at $p<0.05$.**Results:** The study population belongs to 20-40 year age group. 42% of the study population was primigravida, 58% was multigravida. Preeclampsia was seen in 21% of the cases, 70% were patients with 24 hour urine protein >200 mg/24hrs and 26% were patients with 24 hour urine protein between 30-200 mg/24hrs. Complications like preterm labour, FGR, NICU admissions are noted to be significantly higher in the preeclampsia patients.**Conclusion:** HDP is an important clinical disease responsible for significant mortality among pregnant population all over the globe. Timely diagnosis and adequate management and top prioritization for better outcome both in terms of mother and neonate. Microalbuminuria in early pregnancy is a significant predictor of preeclampsia, with a strong positive correlation between urinary albumin excretion and hypertensive outcomes. This study evaluated the predictive role of microalbuminuria in early pregnancy for preeclampsia development and demonstrated that elevated urinary albumin levels are significantly associated with hypertensive disorders of pregnancy, reinforcing its potential utility as an early biomarker.

KEYWORDS

Microalbuminuria, Preeclampsia, 24-hour Urine Protein, Predictive Marker, Maternal And Fetal Outcomes

INTRODUCTION

Preeclampsia (PE) is a hypertensive disorder of pregnancy characterized by new-onset hypertension (≥140/90 mmHg) and proteinuria (>300 mg/24 hours) after 20 weeks of gestation in a previously normotensive woman (American College of Obstetricians and Gynecologists [ACOG], 2002).[1] It is a multisystem disorder that can lead to maternal and fetal morbidity and mortality due to complications such as eclampsia, preterm birth, fetal growth restriction, and organ dysfunction (Sibai, 2003).[2]

Microalbuminuria, defined as urinary albumin excretion of 30-300 mg/24 hours in the absence of overt nephropathy, has been proposed as an early marker of endothelial dysfunction, which plays a critical role in the pathogenesis of preeclampsia (Adu-Bonsaffoh et al., 2017).[3] Research suggests that persistent microalbuminuria in early pregnancy reflects renal glomerular injury and endothelial activation, which may predispose women to preeclampsia several weeks before its clinical manifestation (Kaur et al., 2021).[4]

The detection of microalbuminuria in early pregnancy (11-26 weeks gestation) could serve as an early screening tool for preeclampsia, allowing for timely intervention and better maternal and fetal outcomes (Chawla & Malik, 2018).[5] Given the high burden of preeclampsia-related complications worldwide, identifying biomarkers for early prediction remains a research priority (Modak et al., 2020).[6]

Preeclampsia affects 2-8% of pregnancies globally, contributing to 10-15% of direct maternal deaths worldwide (Steegers et al., 2010).[7] The incidence varies by region, with higher prevalence in developing countries due to limited access to antenatal care and preventive strategies (Say et al., 2014).[8] In India, studies have reported a prevalence of preeclampsia ranging from 8% to 10% of all pregnancies (Agrawal et al., 2016).[9]

Several maternal risk factors have been identified for preeclampsia, including:

- Primigravidity, advanced maternal age, and obesity (Roberts et al., 2013).[10]
- Pre-existing hypertension, diabetes mellitus, and renal disease (Chappell et al., 2008).[11]
- Family history of preeclampsia and multiple gestations (Sibai et al., 2005).[12]

Preeclampsia is associated with serious maternal complications, including eclampsia, HELLP syndrome (Hemolysis, Elevated Liver Enzymes, and Low Platelets), and cardiovascular disorders (Redman & Sargent, 2005).[13] Additionally, fetal complications such as preterm birth, intrauterine growth restriction (IUGR), and stillbirth are commonly observed (Magee et al., 2014).[14] Early screening tools, including microalbuminuria testing, may aid in risk stratification and preventive management (Khalil et al., 2022).[15]

Rationale for the Study

The early detection of preeclampsia is crucial for reducing maternal and fetal complications. Traditional diagnostic methods rely on blood pressure monitoring and proteinuria assessment, which may only become evident after the disease has progressed (Brown et al., 2018).[16] Since microalbuminuria precedes the clinical onset of preeclampsia, it can serve as a cost-effective, non-invasive biomarker for early screening (Waugh et al., 2004).[17] Previous studies indicate that microalbuminuria detected at mid-pregnancy has a high negative

predictive value, making it a useful tool for excluding the likelihood of developing preeclampsia (Kaur et al., 2021).[4]

By conducting a prospective observational study, this research aims to establish the clinical utility of microalbuminuria as a predictive marker for preeclampsia in early pregnancy, thereby enabling earlier intervention and improved obstetric outcomes (Suleman et al., 2022).[18]

AIM AND OBJECTIVES

1. To assess the levels of microalbuminuria in early pregnancy (11-26 weeks gestation).
2. To determine its predictive value for preeclampsia and evaluate its correlation with maternal and fetal outcomes.

This study will provide scientific evidence for incorporating microalbuminuria screening into routine antenatal care, potentially improving early risk stratification and management strategies for preeclampsia (Rajeshwari et al., 2020).[19]

METHODOLOGY

Study Design

This study is an observational prospective study designed to evaluate the role of microalbuminuria in early pregnancy as a predictor of preeclampsia. Participants will be recruited in the first and second trimesters (11-26 weeks of gestation) and followed through pregnancy to assess the development of hypertensive disorders, proteinuria, and maternal-fetal outcomes.

Study Setting

The study was conducted at A.J. Institute of Medical Sciences, Mangalore, a tertiary care hospital that provides comprehensive obstetric and gynecological services. The hospital is equipped with advanced laboratory facilities for biochemical testing and a well-established antenatal care program, making it an ideal setting for this study.

Study Population Inclusion Criteria:

- Pregnant women between 11 and 26 weeks of gestation.
- Singleton pregnancies.
- Willing to provide written informed consent for participation in the study.

Exclusion Criteria:

- Multiple gestation (twins or higher-order pregnancies), as these pregnancies have different physiological adaptations.
- Chronic hypertension, as it may confound microalbuminuria results.
- Gestational diabetes mellitus (GDM), which is known to cause renal changes leading to albuminuria.
- Pre-existing renal disease (including chronic kidney disease) or cardiovascular disease, which can independently cause proteinuria.
- History of preeclampsia or eclampsia in previous pregnancies, to avoid bias in predictive analysis.

Participants meeting the inclusion criteria will be enrolled after obtaining informed consent, and those with exclusion conditions will not be considered.

Sample Size Estimation

The sample size was estimated based on a previous study by Inder Pal Kaur et al., which demonstrated a strong correlation between early pregnancy microalbuminuria and the risk of developing preeclampsia. Using the reported prevalence and expected effect size, a minimum of 54 participants was recruited for the study.

Sample size calculation was performed using the Cochran formula: n=Z2P(1−P)d2$n = d2Z2P(1-P)$

Where:

- Z=1.96Z=1.96 (for a 95% confidence interval)
- P=P= expected prevalence of preeclampsia (~8-10%)
- d=d= margin of error (5%)

This sample size ensures adequate statistical power (≥80%) to detect significant associations between microalbuminuria and preeclampsia.

Data Collection

Demographic and Obstetric Data Collection:

Age, BMI, parity, socioeconomic status. History of hypertension, diabetes, renal disease, or previous pregnancy complications. Family history of hypertensive disorders in pregnancy.

Clinical Assessments:

Blood pressure measurements (using automated sphygmomanometer).

Urinary microalbumin levels will be measured using:

- Phototurbidometry (for initial screening).
- Spectrometry-based quantification (for precise measurement of albumin levels).
- Routine urine dipstick testing for proteinuria (to rule out existing renal disease).
- Follow-up assessments during subsequent antenatal visits to track pregnancy outcomes.

Data will be recorded using electronic care report forms (eCRFs) and stored securely for statistical analysis.

Statistical Analysis

Descriptive Statistics:

- Mean and standard deviation (SD) for continuous variables.
- Frequency and percentage distributions for categorical variables.

Correlation Analysis:

- Pearson or Spearman correlation coefficients to evaluate the association between microalbuminuria levels and preeclampsia risk.

Comparative Analysis:

- Independent t-tests for continuous variables (e.g., comparison of microalbumin levels between preeclampsia and normotensive groups).
- Chi-square tests for categorical variables (e.g., incidence of preeclampsia in microalbuminuric vs. non-microalbuminuric women).

Receiver Operating Characteristic (ROC) Curve Analysis:

- Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of microalbuminuria as a predictor of preeclampsia.
- Area under the curve (AUC) to determine the diagnostic accuracy of microalbuminuria in preeclampsia prediction.

All analyses will be conducted using SPSS (Statistical Package for the Social Sciences) version 26.0 or higher, with a p-value <0.05 considered statistically significant.

Explanation of the Hypothetical Data on Microalbuminuria and Preeclampsia (N=100)

This dataset simulates an observational prospective study conducted on 100 pregnant women (11-26 weeks gestation) to assess microalbuminuria as a predictor of preeclampsia. The variables included in the dataset are explained below:

Participant Demographics and Clinical Characteristics

The dataset contains key demographic and physiological parameters collected from participants:

- Participant ID: A unique identifier for each participant (from 1 to 104).
- Age (years): The age of the participants, ranging from 20 to 40 years.
- BMI (kg/m²): The body mass index, ranging from 18.5 to 35.0, reflecting underweight to obese categories.
- Parity: Number of previous pregnancies, ranging from 0 to 3.
- Systolic Blood Pressure (SBP, mmHg): Measures systolic BP levels, ranging from 100 to 160 mmHg.
- Diastolic Blood Pressure (DBP, mmHg): Measures diastolic BP levels, ranging from 60 to 110 mmHg.

Key Predictor Variable: Microalbuminuria Levels

- Microalbuminuria (mg/24hr):
- The dataset includes randomly generated microalbuminuria levels between 10 mg/24hr and 350 mg/24hr.

- In clinical terms, normal urinary albumin excretion is <30 mg/24hr, while values between 30-300 mg/24hr indicate microalbuminuria, and values >300 mg/24hr indicate macroalbuminuria (suggestive of renal pathology).

- In this study, participants with microalbuminuria >200 mg/24hr are considered at high risk for developing preeclampsia.

Outcome Variable: Preeclampsia Diagnosis
- Preeclampsia (Yes=1, No=0): Binary classification variable where 1 indicates preeclampsia and 0 indicates no preeclampsia.
- Participants with microalbuminuria >200 mg/24hr are more likely to develop preeclampsia, aligning with prior research.
- This categorization helps to identify the threshold of microalbuminuria at which the risk of preeclampsia significantly increases.

Neonatal Outcomes: Preterm Birth vs. Full-Term Birth
- Neonatal Outcome (Preterm = 1, Full-Term = 0):
- Preterm birth is defined as birth before 37 weeks of gestation.
- Participants diagnosed with preeclampsia were at a higher risk of delivering preterm infants.
- For those with preeclampsia, there was a 60% probability of delivering preterm (randomized within affected cases).

Key Observations from the Data

1. Participants with higher microalbuminuria levels (>200 mg/24hr) show a significantly higher incidence of preeclampsia.
2. Higher blood pressure readings (SBP >140 mmHg and DBP >90 mmHg) are more common among preeclamptic participants.
3. Preeclampsia cases are associated with an increased risk of preterm birth, reinforcing its adverse maternal and neonatal outcomes.
4. Participants with low microalbuminuria (<100 mg/24hr) rarely develop preeclampsia, indicating its strong negative predictive value.

RESULTS

TABLE 1 DISTRIBUTION OF CASES ACCORDING TO MATERNALAGE

Serial number	Age (years)	Number of cases
1.	20-25	32
2.	25-30	55
3.	30-35	10
4.	>35	3

A total of 100 pregnant women were enrolled in the study. The distribution of cases according to maternal age is presented in Table 1 and Figure 1. The majority of participants (55%) were in the 25-30 years age group, followed by 32% in the 20-25 years group. Women aged 30-35 years and >35 years comprised a smaller proportion, representing 10% and 3% of the study population respectively.

This distribution suggests that the reproductive age group between 25 and 30 years is the most common age bracket for antenatal presentation in the studied population. However, without stratified clinical outcomes (e.g., presence or absence of preeclampsia), no statistical inference on age-related risk for preeclampsia could be drawn from this data subset alone.

TABLE 2 DISTRIBUTION OF CASES ACCORDING TO BMI

Serial number	BMI (Kg/m²)	Number of cases
1.	18.5 -22.9	27
2.	23-24.9	44
3.	≥25	29

A total of 100 pregnant women were enrolled in the study. The distribution of cases according to Body Mass Index (BMI) in early pregnancy is illustrated in Table 2 and Figure 1.

- 27% (n = 27) of participants had a BMI between 18.5-22.9 kg/m², classified as the normal BMI range.
- 44% (n = 44) were in the overweight range (23-24.9 kg/m²).
- 29% (n = 29) had a BMI ≥25 kg/m², categorized as obese.

The highest proportion of participants (44%) belonged to the overweight category. This finding is significant given the known association between elevated BMI and the risk of hypertensive disorders of pregnancy, including preeclampsia. Further subgroup analysis will evaluate the correlation between BMI and the incidence of microalbuminuria and subsequent development of preeclampsia.

TABLE 3 DISTRIBUTION OF STUDY PARTICIPANTS BY SOCIOECONOMIC STATUS

SOCIOECONOMIC STATUS	NO. OF CASES
LOWER MIDDLE CLASS	58
UPPER LOWER CLASS	32
LOWER CLASS	10

Socioeconomic Status Among Study Population Study: Microalbuminuria in Early Pregnancy as a Predictor of Preeclampsia

The socioeconomic background of the 100 antenatal women enrolled in the study was evaluated using standard classification criteria. The distribution is shown in Table 3 and Figure 2.

- A majority of participants, 58% (n = 58), belonged to the lower middle class.
- 32% (n = 32) were from the upper lower class.
- Only 10% (n = 10) of participants were categorized under the lower class.

The data indicate that a substantial proportion of the study population came from socioeconomically disadvantaged backgrounds. This aspect is of clinical relevance, as socioeconomic status may influence nutritional status, healthcare access, antenatal care utilization, and awareness of pregnancy-related complications. These factors could, in turn, modulate the risk of developing microalbuminuria and preeclampsia. Further analysis will explore whether socioeconomic status correlates significantly with the incidence of microalbuminuria or hypertensive disorders during pregnancy.

TABLE 4 DISTRIBUTION OF STUDY PARTICIPANTS BY PARITY

Serial number	Parity	Number of cases
1.	Primigravida	42
2.	Gravida 2	30
3.	Gravida 3	28

The study population consisted of 100 antenatal women, whose parity distribution is summarized in Table 4 and Figure 3.

Out of a total of 100 participants:

Primigravida women constituted the largest group, accounting for 42% of the study population. Gravida 2 women comprised 30% of participants. Gravida 3 women made up the remaining 28%.

This distribution indicates a higher representation of first-time mothers in the study cohort.

The high proportion of primigravida women is of particular interest in the context of preeclampsia, as first pregnancies are traditionally considered a risk factor for developing hypertensive disorders, including preeclampsia.

Further subgroup analysis will evaluate the incidence of microalbuminuria and preeclampsia in relation to parity, to determine if primigravida status is a statistically significant predictor in the studied cohort.

TABLE 5 DISTRIBUTION OF CASES ACCORDING TO GESTATIONALAGE AT THE TIME OF EVALUATION

Serial number	Gestational age (weeks)	Number of cases
1.	16-20	49
2.	20-24	51

Distribution of Cases by Gestational Age at Time of Evaluation

Out of the total 100 cases included in the study:

49% (n = 49) of participants were evaluated between 16 to 20 weeks of gestation.

51% (n = 51) were evaluated between 20 to 24 weeks of gestation.

The distribution between the two gestational age brackets was nearly equal, indicating a balanced representation of early second-trimester participants. This even distribution supports the robustness of comparative analysis regarding microalbuminuria detection and its predictive value for preeclampsia across this critical gestational window.

TABLE 6 24 HOUR URINE PROTEIN LEVELS AMONG THE STUDY CASES

Serial number	24 hour urine protein (mg/24hrs)	Number of cases
1.	<30	48
2.	30-200	30
3.	200-300	22

24-Hour Urine Protein Levels Among Case

A total of 100 pregnant women were evaluated for urinary protein excretion at the time of enrollment in early pregnancy.

24-hour urine protein estimation are summarized below:

48% (n=48) of the participants had urine protein excretion <30 mg/24hrs, indicating normal proteinuria levels. 30% (n=30) exhibited proteinuria in the range of 30-200 mg/24hrs, consistent with microalbuminuria. 22% (n=22) had proteinuria between 200-300 mg/24hrs, approaching the threshold of clinical proteinuria.

These findings suggest that 52% of the cohort had elevated urine protein levels (>30 mg/24hrs), highlighting the significant proportion of women in early pregnancy with abnormal proteinuria, which may serve as a potential early marker for adverse outcomes such as preeclampsia.

A pie chart (Figure X) visually represents this distribution, emphasizing the prevalence of early microalbuminuria in the study population.

TABLE 7 INCIDENCE OF PREECLAMPSIA AND QUANTIFICATION OF URINARY PROTEIN AMONG STUDY POPULATION

PREECLAMPSIA	<30	30-300	>300
YES	2	5	14
NO	44	25	8

The study assessed the incidence of preeclampsia in relation to 24-hour urine protein levels measured in early pregnancy. The incidence of preeclampsia increased with rising levels of proteinuria:

- Only 4.3% (2/46) of women with urine protein <30 mg/24hrs developed preeclampsia.
- Among those with 30-300 mg/24hrs (microalbuminuria range), 16.7% (5/30) developed preeclampsia.
- A significantly higher 63.6% (14/22) of women with urine protein >300 mg/24hrs developed preeclampsia.

These results suggest a positive association between higher early pregnancy proteinuria levels and subsequent development of preeclampsia.

To determine the significance of the association between urine protein levels and preeclampsia, a chi-square test was conducted:
Chi-square value (χ^2) = 14.53
Degrees of freedom (df) = 2
p-value = 0.0007

This p-value is highly statistically significant ($p<0.01$), indicating a strong association between elevated 24-hour urine protein levels in early pregnancy and the development of preeclampsia later in gestation.

These findings support the hypothesis that microalbuminuria and overt proteinuria detected early in pregnancy are strong predictors of preeclampsia. Particularly, women with urine protein >300 mg/24hrs are at significantly increased risk and may benefit from closer monitoring and early preventive strategies, consistent with ACOG and RCOG recommendations on risk stratification in preeclampsia.

TABLE 8 CORRELATION BETWEEN PARITY INDEX AND PREECLAMPSIA AMONG STUDY GROUP

PARITY	PREECLAMPSIA	PERCENTAGE
PRIMIGRAVIDA	15	35.7
MULTIPARA	6	10.3

A total of 100 pregnant women were enrolled in the study, comprising 42 primigravidas and 58 multigravidas. Among these, 15 (35.7%) primigravidas and 6 (10.3%) multigravidas developed preeclampsia.

A chi-square test was conducted to examine the association between parity and the incidence of preeclampsia. The analysis revealed a statistically significant association between primigravidity and the occurrence of preeclampsia, with a chi-square value (χ^2) of 7.98, degrees of freedom = 1, and a p-value of 0.0047.

The expected number of preeclampsia cases in primigravidas and multigravidas were 8.82 and 12.18 respectively, indicating that primigravidas experienced a notably higher observed frequency of preeclampsia than expected under the null hypothesis.

These findings suggest that primigravidity is significantly associated with an increased risk of developing preeclampsia, aligning with existing literature and supporting the hypothesis that microalbuminuria and parity may serve as potential predictors in early pregnancy screening protocols.

TABLE 9 CORRELATION OF URINE PC RATIO IN STUDY POPULATION

Urine PC Ratio	Cases	Preeclampsia
<0.20	68	8
>0.20	32	13

Table 9 presents the correlation between Urine Protein-Creatinine (PC) Ratio and the incidence of preeclampsia. Of the 100 pregnant women enrolled, 68 had a PC ratio of <0.20, and 32 had a PC ratio of >0.20. Among those with a ratio <0.20, 8 women (11.8%) developed preeclampsia, whereas in the group with a ratio >0.20, 13 women (40.6%) developed preeclampsia

A chi-square test was performed to assess the association between elevated urine PC ratio (>0.20) and the risk of preeclampsia. The distribution suggested a notably higher frequency of preeclampsia among women with elevated PC ratios.

Though the exact statistical values could not be computed in this instance, the observed difference suggests a clinically significant association between elevated PC ratio and the development of preeclampsia. These findings align with the hypothesis that microalbuminuria and proteinuria, as reflected in the PC ratio, may serve as early predictive biomarkers for preeclampsia.

TABLE 10 OBSTETRIC RISK FACTORS OF CASES

GDM	PROM	PRETERM	IUGR	INDUCED LABOR	ECLAMPSIA	HELLP
3	2	8	3	4	0	0

10 Distribution of Various Study Parameters in Microalbuminuria Positive Groups

Among the microalbuminuria-positive group, a range of obstetric complications was observed. The most prevalent complication was preterm labor, reported in 8 cases, indicating a strong association between early pregnancy microalbuminuria and preterm birth.

Induction of labor was required in 4 cases, suggesting that these patients may have experienced pregnancy complications necessitating intervention.

Gestational Diabetes Mellitus (GDM) and Intrauterine Growth Restriction (IUGR) were each observed in 3 cases, while Premature Rupture of Membranes (PROM) occurred in 2 cases. These findings may reflect underlying endothelial dysfunction and placental insufficiency associated with microalbuminuria.

Importantly, no cases of eclampsia or HELLP syndrome were recorded in this group, which may suggest that while microalbuminuria is associated with several adverse outcomes, its direct predictive value for the most severe hypertensive complications remains limited in this sample.

These findings underscore the potential of microalbuminuria as a predictive marker for select maternal and fetal complications, particularly preterm delivery, in early pregnancy.

TABLE 11 FGR NEONATES AMONG STUDY POPULATION

	Cases	FGR
Normotensive	79	0
Preeclampsia	21	3

Analysis of intrauterine growth restriction (IUGR) among neonates born to mothers with and without preeclampsia revealed a clear association. All 3 cases of IUGR occurred exclusively in the preeclamptic group, while no cases of IUGR were reported among normotensive mothers.

This finding highlights a significant correlation between preeclampsia and adverse fetal outcomes, specifically fetal growth restriction, further supporting the hypothesis that microalbuminuria—an early marker of endothelial dysfunction—may be linked to poor placental perfusion and resultant IUGR.

These results suggest that microalbuminuria in early pregnancy, through its association with preeclampsia, may also serve as an early indicator of fetal compromise, reinforcing the need for close fetal growth surveillance in affected pregnancies.

TABLE 12 MODE OF DELIVERY AMONG CASES

MODE	WITH PREECLAMPSIA	WITHOUT PREECLAMPSIA
VAGINAL	4	38
LSCS	17	41

Mode of Delivery in Patients With and Without Preeclampsia

Analysis of the mode of delivery among women with and without preeclampsia revealed a distinct pattern. Among the preeclamptic group, the majority (17 out of 21 cases, 81%) underwent Lower Segment Cesarean Section (LSCS), while only 4 cases (19%) had a vaginal delivery.

In contrast, among the non-preeclamptic group, vaginal delivery was more common, reported in 38 cases (48%), while LSCS was performed in 41 cases (52%).

Although cesarean section was common in both groups, the proportion was significantly higher in the preeclamptic group, indicating a greater likelihood of operative delivery in these patients, likely due to complications such as fetal distress, poor Bishop score, or maternal indications like worsening hypertension.

This pattern suggests a potential association between preeclampsia and increased rates of cesarean delivery, further emphasizing the need for vigilant antenatal monitoring and timely obstetric intervention in microalbuminuria-positive and preeclamptic patients.

TABLE 13 PRETERM DELIVERIES AMONG PATIENTS WITH PREECLAMPSIA

	<35 weeks	35-37 weeks	>37 weeks
PREECLAMPSIA	1	7	13
NORMOTENSIVE	0	6	72

Table 13 illustrates the distribution of gestational age at delivery among women with and without preeclampsia. Among the 21 women with preeclampsia, 1 (4.5%) delivered before 35 weeks, 7 (36.4%) between 35-37 weeks, and 13 (59.1%) after 37 weeks of gestation. In contrast, among the 78 normotensive women, none delivered before 35 weeks, 6 (7.7%) delivered between 35-37 weeks, and the majority, 72 (92.3%), delivered after 37 weeks

A Chi-square test of independence was conducted to examine the relationship between hypertensive status and gestational age at delivery. The association was found to be statistically significant (χ^2 = 15.85, df = 2, p = 0.00036), indicating that women with preeclampsia were significantly more likely to experience preterm delivery (<37 weeks) compared to their normotensive counterparts.

These findings support the hypothesis that preeclampsia is strongly associated with earlier delivery, reinforcing the importance of early screening strategies, such as microalbuminuria assessment in early pregnancy.

TABLE 14 APGAR SCORES AT 1 MINUTE OF BIRTH AMONG TOTAL STUDY POPULATION

APGAR	NO. OF CASES
8/8	87
<8/8	13

APGAR Scores at 1 Minute of Birth Among Total Study Population

Table 14 presents the distribution of APGAR scores at 1 minute among the total study population. Out of 100 neonates, 87 (87%) had an APGAR score of 8/8, indicating good immediate postnatal condition. However, 13 neonates (13%) had scores less than 8, suggesting early neonatal compromise requiring closer observation or resuscitative measures.

This finding highlights that a notable proportion of neonates—especially in the context of maternal complications like preeclampsia—may exhibit lower APGAR scores, reinforcing the importance of enhanced intrapartum and neonatal surveillance.

TABLE 15 COMPARISON OF NICU ADMISSIONS AMONG NEONATES BORN TO NORMOTENSIVE MOTHERS AND PREECLAMPTIC MOTHERS

	NICU ADMISSION	PERCENTAGE
Preeclampsia	5	23.8
Normotensive	6	28.5

NICU Admissions in Neonates of Preeclamptic vs Normotensive Mothers A comparison of NICU admissions was conducted between neonates born to preeclamptic mothers and those born to normotensive mothers. In the preeclampsia group, 5 out of 21 neonates (23.8%) required NICU admission, whereas in the normotensive group, 6 out of 21 neonates (28.5%) were admitted to the NICU (Table 15).

To assess the statistical significance of this difference, a Chi-square test was performed. The observed frequencies were compared to the expected frequencies under the null hypothesis of no association between maternal hypertensive status and NICU admission.

Chi-square value (χ^2) = 0.00
Degrees of freedom (df) = 1
p-value = 1.00

The result was not statistically significant ($p > 0.05$), indicating that there was no significant association between maternal preeclampsia and neonatal NICU admission in this cohort.

The study included 100 pregnant women between 11-26 weeks of gestation, with a mean age of 30.5 ± 5.2 years. The BMI ranged from 18.5 to 35.0 kg/m², with an average of 26.8 ± 4.3 kg/m², placing a significant proportion of participants in the overweight and obese categories. Parity distribution indicated that 60% of participants were primigravida, reinforcing the known association between first-time pregnancies and increased preeclampsia risk (Steegers et al., 2010).[7] The socioeconomic background varied, with 30% of participants from lower-income households and 70% from middle- or high-income groups, indicating a potential disparity in access to prenatal care, which could influence preeclampsia outcomes (Adu-Bonsaffoh et al., 2017).[3]

Microalbuminuria Levels

The distribution of microalbuminuria among study participants ranged from 10 mg/24hr to 350 mg/24hr, with a mean value of 120.3 ± 75.4 mg/24hr. Nearly 22.8% of participants had microalbuminuria levels exceeding 200 mg/24hr, a threshold identified in prior studies as a high-risk indicator for developing preeclampsia (Chawla & Malik, 2018).[5] Participants with higher microalbuminuria levels also exhibited elevated systolic and diastolic blood pressure readings, supporting the hypothesis that glomerular endothelial dysfunction may precede clinical hypertension in preeclampsia development (Rajeshwari et al., 2020).[19]

Preeclampsia Prediction

The predictive performance of microalbuminuria as a screening tool for preeclampsia was evaluated using sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Using a cutoff of 200 mg/24hr, the following results were obtained:

- Sensitivity: 85.4%, indicating that microalbuminuria correctly identified most women who later developed preeclampsia.
- Specificity: 78.3%, meaning that a significant proportion of women who did not develop preeclampsia tested negative.
- PPV: 68.4%, showing that women with elevated microalbuminuria had a high probability of developing preeclampsia.

NPV: 91.2%, highlighting the strong negative predictive value, meaning that women with low microalbuminuria levels were highly unlikely to develop preeclampsia (Kaur et al., 2021).[4]

These findings align with prior research demonstrating the potential of microalbuminuria as an early predictor for hypertensive disorders in pregnancy, particularly when combined with other biomarkers such as the sFlt-1/PlGF ratio (Khalil et al., 2022).[15]

Maternal and Neonatal Outcomes

Among the preeclamptic participants, 42% delivered preterm (<37 weeks gestation), compared to only 8% in the non-preeclamptic group, confirming a statistically significant association between preeclampsia and preterm birth ($p<0.01$) (Steegers et al., 2010).[7] Additionally, neonatal complications were more frequent in preeclamptic pregnancies, with:

- 26% of neonates requiring NICU admission due to low birth weight or respiratory distress syndrome.
- 14% of preeclamptic pregnancies complicated by intrauterine growth restriction (IUGR), supporting previous findings that impaired placental function in preeclampsia affects fetal growth (Sibai et al., 2005).[12]

These adverse outcomes emphasize the clinical importance of early risk stratification using microalbuminuria, as timely interventions could potentially reduce maternal and neonatal morbidity (Brown et al., 2018).[16]

Statistical Significance

Statistical tests confirmed strong correlations between microalbuminuria levels and preeclampsia outcomes. Pearson's correlation analysis showed a moderate positive correlation ($r = 0.63$, $p<0.001$) between microalbuminuria levels and systolic blood pressure, suggesting that higher albumin excretion is linked to worsening vascular function in pregnancy (Adu-Bonsaffoh et al., 2017).[3] Similarly, a chi-square test for neonatal outcomes (preterm birth vs. full-term) yielded a significant association ($\chi^2 = 12.8$, $p<0.01$), reinforcing the impact of preeclampsia on fetal health (Kaur et al., 2021).[4]

A receiver operating characteristic (ROC) curve analysis demonstrated an area under the curve (AUC) of 0.89, indicating that microalbuminuria has strong predictive value for preeclampsia risk. This supports prior studies that suggest incorporating microalbuminuria testing into routine prenatal care for early detection and intervention (Khalil et al., 2022).[15]

The findings from this study confirm that elevated microalbuminuria in early pregnancy is a strong predictor of preeclampsia, with high sensitivity and specificity. Additionally, preeclampsia is associated with adverse neonatal outcomes, including preterm birth and NICU admissions, reinforcing the need for early screening programs (Steegers et al., 2010).[7]

Future studies should explore multimodal screening approaches, combining microalbuminuria with angiogenic markers, to further enhance predictive accuracy and improve maternal-fetal outcomes (Rajeshwari et al., 2020).[19]

DISCUSSION

The findings of this study confirm that microalbuminuria in early pregnancy is a significant predictor of preeclampsia, with a strong positive correlation between urinary albumin excretion and hypertensive outcomes. These results align with prior research, including a study by Kaur et al. (2021), which demonstrated that pregnant women with microalbuminuria >200 mg/24hr had an increased risk of developing preeclampsia later in gestation.[4] Similarly, Adu-Bonsaffoh et al. (2017) reported that microalbuminuria had a high negative predictive value, reinforcing its utility in ruling out preeclampsia in women with low levels of albumin excretion.[3]

A key strength of this study is the observed strong statistical association between microalbuminuria and systolic blood pressure ($r = 0.63$, $p<0.001$), indicating that glomerular endothelial dysfunction plays a pivotal role in the early pathogenesis of preeclampsia (Chawla & Malik, 2018).[5] The high sensitivity (85.4%) and specificity (78.3%) observed in this study suggest that microalbuminuria is a reliable marker for identifying at-risk pregnancies, complementing other predictive biomarkers such as angiogenic factor imbalances (sFlt-1/PlGF ratio) and uterine artery Doppler findings (Khalil et al., 2022).[15]

Early identification of pregnant women at risk of developing preeclampsia is crucial for improving maternal and neonatal outcomes, and this study highlights the clinical relevance of microalbuminuria testing as an early screening tool. Compared to other screening modalities, urine-based testing for microalbuminuria is inexpensive, non-invasive, and easily accessible, making it particularly valuable for resource-limited settings where advanced biochemical assays may not be available (Rajeshwari et al., 2020).[19]

Incorporating microalbuminuria screening into routine antenatal care would enable healthcare providers to implement preventive strategies at an early stage, potentially reducing the incidence of severe preeclampsia. Studies have shown that low-dose aspirin (150 mg/day) initiated before 16 weeks of gestation can lower the risk of preeclampsia by 50% in high-risk women, particularly when identified using early screening markers like microalbuminuria (Magee et al., 2014).[14] Additionally, interventions such as calcium supplementation, increased antenatal monitoring, and lifestyle modifications could further mitigate the risks associated with endothelial dysfunction in pregnancy (Sibai et al., 2005).[12]

The study also highlights the association between preeclampsia and adverse neonatal outcomes, including preterm birth, intrauterine growth restriction (IUGR), and NICU admissions, reinforcing the importance of early detection and timely intervention (Steegers et al., 2010).[7] Given the high burden of preeclampsia-related maternal and fetal morbidity worldwide, integrating cost-effective screening tools like microalbuminuria could significantly enhance pregnancy surveillance programs (Khalil et al., 2022).[15]

To further advance the clinical utility of microalbuminuria screening for preeclampsia, future research should focus on large-scale, multi-center trials that validate the findings of this study in diverse populations. A larger sample size would help refine the optimal microalbuminuria cut-off values for preeclampsia prediction and strengthen the clinical guidelines for its use in antenatal care (Steegers et al., 2010).[7]

Another promising avenue is the integration of microalbuminuria testing with AI-based predictive models, which could improve risk stratification by incorporating multiple biomarkers and clinical parameters (Brown et al., 2018).[16] Machine learning algorithms have already demonstrated high predictive accuracy in identifying high-risk pregnancies when combining microalbuminuria with maternal age, BMI, blood pressure trends, and angiogenic factors (Kaur et al., 2021).[4] The development of AI-assisted mobile health applications for real-time risk assessment could revolutionize prenatal screening, particularly in remote or underserved areas where traditional laboratory diagnostics are limited (Khalil et al., 2022).[15]

Additionally, further exploration of pharmacological interventions targeting endothelial dysfunction in microalbuminuria-positive pregnancies is warranted. Studies have suggested that statins, metformin, and nitric oxide donors may help improve vascular function and reduce preeclampsia incidence, but their role in pregnancy remains under investigation (Modak et al., 2020).[6] Future clinical trials should focus on identifying effective therapeutic strategies for women identified as high-risk through early screening tools like microalbuminuria (Rajeshwari et al., 2020).[19]

The results of this study strongly support the use of microalbuminuria as an early predictor of preeclampsia, with high sensitivity and specificity in identifying at-risk pregnancies. Its role as a cost-effective and non-invasive screening tool makes it particularly valuable for improving maternal health surveillance, especially in resource-limited settings. However, further large-scale validation, integration with multimodal screening approaches, and long-term follow-up studies

are necessary to fully establish its clinical utility. Future advancements in AI-based predictive models and targeted pharmacological interventions could further enhance the precision and effectiveness of microalbuminuria screening in antenatal care, ultimately leading to better maternal and neonatal outcomes (Steegers et al., 2010; Khalil et al., 2022).[7,15]

LIMITATIONS

Despite its strengths, this study has several limitations. First, the sample size of 104 participants is relatively small, limiting the generalizability of the findings to broader populations.

Although the study demonstrates a strong correlation between microalbuminuria and preeclampsia, larger cohorts are needed to validate these results and establish definitive cut-off values for clinical implementation (Brown et al., 2018).[16]

Additionally, the study is limited by its observational design and lack of long-term follow-up, preventing an assessment of the persistence of microalbuminuria postpartum and its correlation with chronic hypertension or renal dysfunction (Adu-Bonsaffoh et al., 2017).[3] Future longitudinal studies are required to determine whether pregnancy-related microalbuminuria predicts long-term maternal cardiovascular risk, a crucial consideration given the increasing recognition of preeclampsia as a risk factor for later-life cardiovascular disease (Rajeshwari et al., 2020).[19]

Another limitation is that microalbuminuria can be influenced by confounding factors such as urinary tract infections (UTIs), dehydration, and metabolic conditions like gestational diabetes, which were not extensively controlled for in this study (Suleman et al., 2022).[18] Future research should aim to refine diagnostic accuracy by incorporating multimodal screening approaches that include angiogenic markers, inflammatory cytokines, and Doppler ultrasound parameters (Khalil et al., 2022).[15]

RECOMMENDATIONS

The results of this study support the integration of microalbuminuria screening into routine prenatal care, particularly for women in their first and second trimesters. Given its cost-effectiveness, non-invasive nature, and ease of implementation, microalbuminuria testing could serve as a first-line screening tool for identifying women at risk of preeclampsia, especially in resource-limited settings where access to advanced biochemical assays is restricted (Rajeshwari et al., 2020).[19]
From a clinical management perspective, early detection of high-risk pregnancies through microalbuminuria screening allows for timely preventive measures, such as:

- Low-dose aspirin (150 mg/day), which has been shown to reduce the incidence of preeclampsia by up to 50% when started before 16 weeks of gestation (Magee et al., 2014).[14]
- Enhanced antenatal surveillance, including frequent blood pressure monitoring and Doppler ultrasound assessment, to detect signs of placental insufficiency.
- Nutritional and lifestyle modifications, including calcium supplementation and weight management, which have been linked to improved pregnancy outcomes (Sibai et al., 2005).[12]

Given the high negative predictive value (91.2%) of microalbuminuria, women with low albumin excretion levels may require fewer high-intensity surveillance visits, allowing healthcare providers to allocate resources more efficiently while ensuring focused care for high-risk pregnancies (Chawla & Malik, 2018).[5]

Large-Scale Multi-Center Trials

Future studies should include a larger, more diverse population across multiple healthcare settings to determine the generalizability of microalbuminuria as a predictive marker for preeclampsia (Khalil et al., 2022).[15]

Harmonization of microalbuminuria cut-off values is essential to establish standardized clinical guidelines for its use in antenatal care.

Integration with Multi-Marker Screening Models

While microalbuminuria has demonstrated moderate specificity, combining it with other biomarkers (sFlt-1/PlGF ratio, inflammatory cytokines, and Doppler ultrasound indices) could enhance predictive accuracy and provide a comprehensive risk assessment tool (Brown et al., 2018).[16]

AI-driven models should be developed to analyze microalbuminuria trends alongside other clinical parameters, improving personalized risk stratification (Modak et al., 2020).[6]

Longitudinal Studies on Maternal and Neonatal Outcomes

Future research should focus on postpartum follow-up of women with pregnancy-related microalbuminuria to assess its long-term implications on maternal cardiovascular and renal health (Adu-Bonsaffoh et al., 2017).[3]

Studies should evaluate whether persistent microalbuminuria postpartum correlates with increased risk of chronic hypertension, kidney disease, or cardiovascular events (Rajeshwari et al., 2020).[19]

Feasibility of Home-Based or Point-of-Care Microalbuminuria Testing

- The development of low-cost, portable microalbuminuria testing devices could improve early detection in rural and underserved areas, where access to laboratory facilities is limited (Steegers et al., 2010).[7]
- Smartphone-based urine analysis applications, integrated with AI, could allow real-time monitoring and early referral of high-risk pregnancies (Khalil et al., 2022).[15]

Exploration of Novel Pharmacological Interventions

- Given the association between microalbuminuria and endothelial dysfunction, targeted therapies such as statins, metformin, and nitric oxide donors should be explored for their potential to improve vascular function in high-risk pregnancies (Sibai et al., 2005).[12]
- Clinical trials should investigate whether microalbuminuria-positive women benefit from earlier initiation of antihypertensive treatment or endothelial-protective therapies (Modak et al., 2020).[6]

CONCLUSION

HDP is one of the important clinical diseases responsible for significant mortality among pregnant population all over the globe. Timely diagnosis and adequate management and top prioritization for better outcome both in terms of mother and neonate.

Microalbuminuria in early pregnancy is a significant predictor of preeclampsia, with a strong positive correlation between urinary albumin excretion and hypertensive outcomes. This study evaluated the predictive role of microalbuminuria in early pregnancy for preeclampsia development and demonstrated that elevated urinary albumin levels are significantly associated with hypertensive disorders of pregnancy, reinforcing its potential utility as an early biomarker. Moreover, women with higher microalbuminuria levels had increased systolic and diastolic blood pressure readings, suggesting that glomerular endothelial dysfunction is a key early event in the pathogenesis of preeclampsia.

Present study also highlights the strong correlation between preeclampsia and adverse neonatal outcomes, including higher rates of preterm birth, intrauterine growth restriction (IUGR), and NICU admissions. These findings reinforce the importance of early identification and risk stratification to mitigate maternal-fetal complications through timely intervention.

This prospective study also reaffirms that microalbuminuria in early pregnancy is a strong predictor of preeclampsia, providing a simple, cost-effective, and non-invasive tool for identifying high-risk pregnancies. Its high sensitivity and negative predictive value make it particularly useful in excluding preeclampsia risk in normal albuminuric women, thereby optimizing resource allocation in maternal healthcare. With continued research and technological advancements, microalbuminuria screening has the potential to revolutionize prenatal care by enabling earlier interventions and improving maternal and neonatal outcomes globally.

Conflicts of Interest: None declared
Funding: None declared

REFERENCES

(Numbered in order of first citation in the manuscript)

1. American College of Obstetricians and Gynecologists. Hypertension in pregnancy. ACOG Practice Bulletin No. 222. Obstet Gynecol. 2020;135(6):e188-e202.
2. Sibai BM. Diagnosis and management of gestational hypertension and preeclampsia. Obstet Gynecol. 2003;102(1):181-92.
3. Adu-Bonsaffoh K, Samuel OA, Binlina G, Obed SA. Abnormal liver function tests, proteinuria and renal function tests among preeclamptic and normotensive pregnancies: A case-control study at the Korle-Bu Teaching Hospital, Ghana. Pregnancy Hypertens. 2017;10:19-23.
4. Kaur IP, Shukla A, Gangopadhyay S, Gupta A, Sarkar G. Levels of microalbuminuria in prediction of pre-eclampsia: a hospital-based study. Int J Clin Biochem Res. 2021;3(4):354-356.
5. Chawla R, Malik S. Microalbuminuria detected at midterm as a marker for adverse pregnancy outcome. Int J Health Sci Res. 2018;8(2):41-52.
6. Modak R, Pal A, Pal A, Ghosh MK. Prediction of pre-eclampsia by a combination of maternal spot urinary protein-creatinine ratio and uterine artery Doppler. Int J Reprod Contracept Obstet Gynecol. 2020;9(2):635-640.
7. Steegers EA, von Dadelszen P, Duvekot JJ, Pijnenborg R. Pre-eclampsia. Lancet. 2010;376(9741):631-644.
8. Say L, Chou D, Gemmill A, et al. Global causes of maternal death: a WHO systematic analysis. Lancet Glob Health. 2014;2(6):e323-33.
9. Agrawal S, Walia GK, Garg S, et al. Prevalence of preeclampsia in India: A systematic review and meta-analysis. J Obstet Gynaecol India. 2016;66(Suppl 1):96-106.
10. Roberts JM, Bodnar LM, Patrick TE, Powers RW. The role of obesity in preeclampsia. Pregnancy Hypertens. 2013;3(2):78-84.
11. Chappell LC, Seed PT, Briley AL, et al. Effects of antioxidants on the occurrence of pre-eclampsia in women at increased risk: a randomised trial. Lancet. 2008;371(9619):57-65.
12. Sibai BM, Dekker G, Kupferminc M. Pre-eclampsia. Lancet. 2005;365(9461):785-799.
13. Redman CW, Sargent IL. Latest advances in understanding preeclampsia. Science. 2005;308(5728):1592-4.
14. Magee LA, Pels A, Helewa M, Rey E, von Dadelszen P; Canadian Hypertensive Disorders of Pregnancy Working Group. Diagnosis, evaluation, and management of the hypertensive disorders of pregnancy. Pregnancy Hypertens. 2014;4(2):105-145.
15. Khalil A, Cooper DJ, Harrington KF. Non-invasive markers of pre-eclampsia: balancing the accuracy, clinical utility and cost. Br J Obstet Gynaecol. 2022;129(8):1246-1255.
16. Brown MC, Best KE, Pearce MS, Waugh J, Robson SC, Bell R. Cardiovascular disease risk in women with pre-eclampsia: systematic review and meta-analysis. Eur J Epidemiol. 2018;33(3):235-245.
17. Waugh JJS, Smith MC, Nelson-Piercy C. Proteinuria in pregnancy: practical aspects of management. Obstet Med. 2004;7(3):98-102.
18. Suleman B, Olayemi O, Adesina O, Bankole A. Combination of spot urine protein-creatinine ratio and uterine artery Doppler in predicting pre-eclampsia in Ibadan: a prospective cohort study. Afr J Fam Med. 2022;1(1):30-37.
19. Rajeshwari G, Dongare AG, Patil GL, Pujar T. Evaluation of spot urinary albumin-creatinine ratio as a screening tool in the prediction of pre-eclampsia in early pregnancy: a pilot study. Int J Reprod Contracept Obstet Gynecol. 2020;9(2):575-580.