Media Kesehatan Politeknik Kesehatan Makassar

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

Association Between Seasonal Variation and Hypertension in Pregnancy at Anna Medika Madura Hospital

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Article Information: Received February 2026; Accepted June 2026; Published June 2026

ABSTRACT

Hypertension in Pregnancy are classified as follows: chronic hypertension, preeclampsia/eclampsia, chronic hypertension with superimposed preeclampsia and gestational hypertension. Hypertensive problems in pregnancy particularly pre eclampsia and eclampsia afflicts nearly 28% of pregnant women globally and are an important cause of maternal and neonatal morbidity and mortality. First-time mothers with a previous pregnancy termination, a high body mass index and a paternal effect are at a higher risk of developing pre-eclampsia. Again, Mediterranean seasonal pattern documentation showed variations in severe preeclampsia rates; all of which warrant a more comprehensive study. The purpose of this study is to analyze the relationship between seasonal variations and hypertension in pregnancy. This study used an analytical cross-sectional design. The independent variable in this study was seasonal variation, while the dependent variable was the incidence of hypertension in pregnancy. The study population consisted of 1,210 pregnant women registered in the medical records of ANNA Medika Madura General Hospital from January 1 to December 31, 2025, with a sample size of 291 pregnant women determined using the Lemeshow formula, based on the inclusion criterion of residing in Madura. . The exclusion criterion in this study was incomplete medical records and chronic hypertension . The sampling technique used stratified random sampling. Statistical analysis used chi-square test only; no adjustment for potential confounders was performed. During the dry season, 24% of pregnant women had hypertension, while 76% did not. Conversely, during the rainy season, the incidence of hypertension in pregnancy was higher than during the dry season, at 33%, with 67% of pregnant women not having hypertension. Statistical analysis results indicate a significant association between seasonal variations and the incidence of hypertension in pregnancy ($p = 0.024$), suggesting that the incidence of hypertension in pregnancy differs significantly between the dry season and the rainy season. Seasonal variations are significantly associated with hypertension in pregnancy, with a higher number of cases during the rainy season compared to the dry season. Healthcare providers are advised to intensify antenatal monitoring during the rainy season, particularly for pregnant women with risk factors. Strategies for prevention, early detection, and management of hypertension in pregnancy need to be further optimized. Additionally, further research is recommended to investigate the mechanisms underlying this association and to develop season-specific intervention strategies.

Keywords: Seasonal Variation; Hypertension; Pregnancy

INTRODUCTION

Hypertensive conditions are the commonest complications that occur during pregnancy medically. Worldwide estimates suggest that between 3–8% of all pregnancies are affected by these disorders, and the rates continue to rise[1] [2]The burden of hypertensive complications during pregnancy inflicts a major impact on both the mother and the unborn baby. It stands out as one of the most common causes of maternal and perinatal illness and death. In resource-constrained nations within low- and middle-income groups, it is the third most common reason for maternal death, so this problem is quite acute [3], so diagnosis and treatment of patients must be done immediately. In pregnant women, hypertension during pregnancy is closely associated with various pregnancy-related diseases and an increased risk of cardiovascular, renal, and cerebrovascular diseases in the future[4] [5]In addition, the season also plays a role in the risk of hypertension in pregnant women, as indicated by a study conducted at Sanandaj Besat Hospital from 2013 to 2014, which found that the risk of preeclampsia is higher in the winter than in the warmer months[6] · Madura has distinct seasonal patterns namely, a dry season and a rainy season which facilitate the analysis of seasonal effects on hypertension. The population of Madura is relatively homogeneous, simplifying the control of demographic variables. Easy access to health data and collaboration with local health facilities, as well as Madura's relatively dry and hot climate, may influence the lifestyle and health of pregnant women.

Pregnancy-induced hypertension can be divided into four categories. Chronic hypertension. Preeclampsia/eclampsia. Chronic hypertension with superimposed preeclampsia. Gestational Hypertension. Gestational hypertension is defined as the occurrence of hypertension (systolic ≥ 140 mmHg and/or diastolic ≥ 90 mmHg) after 20 weeks of gestation. To confirm hypertension in pregnant women, blood pressure requires monitoring either at assessment unit visits of 4–6 hours or during admission to the hospital. Around 10% of

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

pregnancies affected by hypertension, which is considered the most common medical complication. This can include chronic hypertension, gestational hypertension (GH) as well as preeclamsia (PE)[7]

Every year, about 10 million women in the world develop pre-eclampsia[8] and about four million women diagnosed with preeclampsia contribute to over 70,000 maternal deaths and about 500,000 neonatal deaths[4]. Have reported that direct links of the eclampsia and preeclampsia account for 10-15% of the maternal deaths globally. Outcomes in settings with limited resources are profoundly worse, linked to poor antenatal care monitoring, as well as delays in diagnosis and management[9] . Ethiopian studies have documented perinatal mortality rates linked to hypertensive disorders in pregnancy reaching 111 per 1,000 live births—among the world's highest figures[10] . A retrospective hospital-based investigation in Ethiopia revealed that preeclampsia and eclampsia contributed to 35% of maternal mortality cases, underscoring how critically these conditions impact both maternal and fetal health outcomes[9]. At Anna Medika General Hospital, 10 pregnant women with hypertension were recorded in October 2025. Preeclampsia is influenced by various predisposing factors, including maternal age < 20 years or > 35 years, multiple pregnancies, history of preeclampsia, first pregnancy, and comorbid conditions such as kidney disease, chronic hypertension, or diabetes mellitus. Nulliparity has also been identified as a risk factor for preeclampsia related to immunological response. The risk of preeclampsia in nulliparous women increases with a history of abortion, high body mass index, paternal factors and seasonal variations.

Research by Daniilidis et al. in Syahadatina et al., (2021) examined seasonal variations in the incidence of severe preeclampsia in Mediterranean climates. The results of this study indicate that severe preeclampsia occurs most frequently during the summer. These findings suggest the possibility of new mechanisms involved in the pathogenesis of severe preeclampsia across different seasons, specifically during the summer. Metabolic adaptations during the summer may trigger the production of vasoactive substances and fluid retention as the body's physiological response to protect itself from dehydration[11].. In the context of global climate change, and with epidemiological evidence continuing to grow, it is clear that abnormal environmental temperatures can increase the risk of various cardiovascular and respiratory diseases as well as perinatal diseases[12] . Given that hypertension in pregnancy is a specific cardiovascular disease that occurs during pregnancy, environmental temperature is thought to play an important role as a risk factor for hypertension in pregnancy. Most previous studies have assessed the effect of seasonal variation on the prevalence of hypertension in pregnancy and have produced mixed findings. Compared to other seasons, a lower prevalence of hypertension in pregnancy has been reported in women who give birth in the fall or summer, or who conceive in the fall. These findings indicate that seasonal factors independently influence hypertension in pregnancy. The role of environmental temperature as one of the main variables causing seasonal variations in the development of HDPs has not been widely explored. A recent preliminary study reported a relationship between environmental temperature and preeclampsia as a subtype of hypertension in pregnancy [13]

Maternal complications, such as stroke (cerebrovascular accident/CVA), acute renal failure (ARF), hemolysis, elevated liver enzymes and HELLP syndrome (hemolysis, elevated liver enzymes, and low platelets), placental abruption, and maternal death, still show high rates. Given the magnitude of maternal and fetal complications associated with preeclampsia and eclampsia as significant public health issues, this study is an effort to evaluate the incidence of hypertension in pregnancy that may be related to seasonal variations.

MATERIALS AND METHODS

Study Design

The study design was analytical with a cross-sectional approach to examine the prevalence of hypertension in pregnancy based on seasonal variations, namely the rainy season and the dry season. The rainy season was defined as occurring from October to April, while the dry season occurred from may to September. This study was conducted at ANNA Medika Madura General Hospital using medical records of all pregnancies recorded between January 1 and December 31, 2025. Pregnancy-induced hypertension is defined as a systolic blood pressure (SBP) of ≥ 140 mmHg and/or a diastolic blood pressure (DBP) of ≥ 90 mmHg in two repeated measurements taken 15 minutes apart while the patient is lying supine. The diagnosis is based on the patient's medical records, which may include pregnancy-induced hypertension, and preeclampsia.

Sample Method and participants

The study population (N) consisted of 1,210 pregnant women registered in the medical records of ANNA Medika Madura General Hospital from January 1 to December 31, 2025, with a sample size of 291 pregnant women was determined using the Lemeshow formula. The sampling technique used systematic random sampling, in which the percentage for each month was identified from the total population; this percentage was used as the basis for the percentage of samples randomly selected each month from patient medical records, with the inclusion criteria of residing in Madura and the exclusion criteria of incomplete medical records and chronic hypertension. The independent variable in this study is seasonal variation, while the dependent variable is the incidence of hypertension in pregnancy

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

Data Collection

Data collection on pregnant women from the medical records of Anna Medika Madura General Hospital began with the identification of relevant data sources, as well as obtaining official permission from Anna Medika Madura General Hospital and research ethics approval from Noor Huda Mustofa University. Diagnoses were determined based on data in the medical records to classify respondents into the categories of gestational hypertension or normotensive pregnancy. Blood pressure data for pregnant women were collected during the first visit. The sample size was determined based on a percentage corresponding to the population proportion for each month. The data used were then selected based on pre-established inclusion and exclusion criteria. Research variables were extracted from the data sources using a structured data collection form, followed by a coding and anonymization process to maintain subject confidentiality

Statistical analysis

Data analysis was performed using the Chi-square test with SPSS version 23. The stages of data collection to data analysis went through the process of identifying and tracing hospital medical records that met the criteria using medical record numbers or the hospital information system (SIMRS). The initial stage involved data extraction, where data that met the inclusion and exclusion criteria were collected using an observation sheet or data extraction sheet that had been prepared in advance by the researcher, covering demographic, clinical, and supporting examination variables as required by the study. Next, the data coding and anonymization stage is carried out, where all patient data is coded and their personal identities are removed to maintain the confidentiality and privacy of the research subjects. Data completeness and validation checks are carried out in the next stage to be rechecked to ensure data completeness and accuracy before analysis. The final stage is the processing and analysis of valid data, which is then input into statistical software for analysis in accordance with the research design.

Ethics Considerations

Ethical approval for this study was obtained from the Noor Huda Mustofa University Ethics Committee, and all research procedures were carried out in accordance with applicable research ethics standards (No. 2984/KEPK/UNIV-NHM/EC/XII/2025).

RESULTS

Table 1. Distribution of Respondent Characteristics Based on IMT and parity

Variables	n	%
Body mass index (BMI)		
Underweight	6	3
Normal	24	8
Overweight	261	89
Parity		
Primiparous	152	52
Multiparous	126	43
Grandemultiparous	13	5
Maternal age		
Younger than 20 years	4	1,4
20-29 years	134	46
30-39 years	129	44,3
40 years or older	24	8,3

Source: Secondary Data from Anna Medika Hospital, 2025

Table 1 presents the distribution of respondents based on body mass index (BMI) and parity. The majority of respondents fell into the high BMI category, totaling 261 individuals (89%). Respondents with a normal BMI numbered 24 (8%), while those with a low BMI constituted the smallest group, comprising 6 individuals (3%). Based on parity, the primiparous group constituted the largest proportion, totaling 152 individuals (52%). This was followed by the multiparous group, comprising 126 individuals (43%). The grandemultiparous group was the smallest subgroup, consisting of 13 individuals (5%). Maternal age is also shown in this table, where the majority (46%) of mothers were aged 20–29 years. 44.3% were pregnant women aged 30–39 years, and a small proportion 8.3% were over 40 years old and 1.4% were under 20 years old. According to researchers, although there is no association between age and the incidence of hypertension in pregnant women, age remains a risk factor for the

https://doi.org/ 10.32382/medkes.v21i1

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

occurrence of hypertension in pregnant women; this is because hypertension is more commonly found during the early and late stages of reproductive age, namely adolescence or over 35 years of age. Pregnant women under 20 years of age are more prone to elevated blood pressure and are more likely to experience seizures, while those over 35 years of age also face a higher risk of developing hypertension. Therefore, women in the early or late stages of reproductive age are more susceptible to developing hypertension during pregnancy [14].

Table 2. Overview of the Incidence of Hypertensive Disorders of Pregnancy by Month

NO	Month	Number of Pregnant Women	Hypertension in Pregnancy			
			Hypertension		No Hypertension	
			N	%	N	%
1	January	19	5	26	14	74
2	February	19	4	21	15	79
3	March	24	11	46	13	54
4	April	23	10	43	13	57
5	May	25	6	24	19	76
6	June	25	11	44	14	56
7	July	25	5	20	20	80
8	August	27	3	11	24	89
9	September	27	7	26	20	74
10	October	28	6	21	22	79
11	November	24	10	42	14	58
12	December	23	10	43	13	57

Source: Secondary Data from Anna Medika Hospital, 2025

Table 2 shows the distribution of hypertension cases in pregnancy by month during the study period. The rainy season from October to April showed relatively high numbers in November (42%), December (43%), and March (46%), with the number of pregnant women with hypertension in March, which is the transition month from the rainy season to the dry season, slightly higher than in November and December. During the dry season from May to September, the incidence of hypertension in pregnancy increased in June (44%). Conversely, the lowest proportion was found in August (11%), followed by July (20%). Throughout the entire period of the study, most pregnant women did not experience hypertension, with the highest proportion of pregnancies without hypertension occurring in August (89%) and July (80%), both of which were during the dry season. Overall, the results of the study show fluctuations in the incidence of hypertension in pregnancy between months without a consistent or uniform pattern throughout the year.

Table 3. Overview Effect of Seasonal Variation on the Occurrence of Hypertension in Pregnancy

season	Hypertension in Pregnancy						pvalue
	No Hypertension		Hypertension		Total		
	n	%	n	%	n	%	
Dry season	137	76	44	24	181	100	0,024
Rainy season	69	67	41	33	110	100	

Source: Secondary Data from Anna Medika Hospital, 2025

Table 3 shows the relationship between seasonal variations and the incidence of hypertension in pregnancy. During the dry season, 24% of pregnant women had hypertension, while 76% did not. Conversely, during the rainy season, the incidence of hypertension in pregnancy was higher than during the dry season, at 33%, with 67% of pregnant women not having hypertension. Statistical analysis results indicate a significant association between seasonal variations and the incidence of hypertension in pregnancy ($p = 0.024$), suggesting that the incidence of hypertension in pregnancy differs significantly between the dry season and the rainy season.

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e-ISSN : 2549-0567 (Online)

DISCUSSION

Global temperature changes play role in human health. Although some studies suggest that exposure to environmental temperatures may affect pregnancy outcome, there is no definitive evidence that air temperature or clima te influences the incidence of preeclampsia[15]The findings of this study indicate that the prevalence of pregnancy-induced hypertension is higher during the rainy season compared to the dry season, and statistically demonstrate a significant association between seasonal variations and the incidence of hypertension in pregnant women.

The rainy season from October to April showed relatively high numbers in November (42%), December (43%), and March (46%), with the number of pregnant women with hypertension in March, which is the transition month from the rainy season to the dry season, being slightly higher than in November and December. During the dry season from May to September, the incidence of hypertension in pregnancy increased in June (44%). Conversely, the lowest proportion was found in August (11%), followed by July (20%). Throughout the entire period of the study, most pregnant women did not experience hypertension, with the highest proportion of pregnancies without hypertension occurring in August (89%) and July (80%), both of which were during the dry season. Pabarja's research shows that the highest prevalence of pregnancy-induced hypertension occurs in winter, particularly in January and February, while the lowest prevalence of pregnancy-induced hypertension occurs in autumn, particularly in September and November[16]. Both studies share similarities in the number of hypertension cases, with the highest prevalence occurring during the rainy season in this study and during the winter season in Pabarja's study.

Based on the BMKG's dry season forecast for the seasonal zones (ZOM) in Indonesia in 2024, the rainy season in the Madura region generally lasts from October to April, while the dry season occurs from May to September, with variations in season duration that can differ each year[17] . Fura's (2020) research reports that Madura Island, as part of East Java Province, has heterogeneous rainfall characteristics between regions, with several rain stations recording extreme rainfall events that vary spatially and temporally[18] . These local climatic conditions are relevant to consider in the context of physiological adaptation during pregnancy, including the development of hypertensive disorders that may be influenced by environmental factors such as rainfall variability. Cold temperature can trigger vasoconstriction as a physiological response to maintain body heat, which can ultimately lead to increased blood pressure.

Table 1 presents the distribution of respondents based on body mass index (BMI) and parity. Most respondents were in the high BMI category, namely 261 people (89%). Respondents with normal BMI numbered 24 people (8%), while respondents with low BMI were the smallest group, namely 6 people (3%). Based on parity, the primipara group constituted the largest proportion, namely 152 people (52%). Next was the multipara group, numbering 126 people (43%). The grandemultipara group was the smallest subgroup, numbering 13 people (5%). . The incidence of preeclampsia is influenced by various factors, including parity, ethnicity, genetic predisposition, maternal age over 35 years, and systemic conditions such as hypertension, diabetes mellitus, chronic kidney disease, and endocrine disorders. Environmental factors, including living in high altitudes, obesity, and multiple pregnancies, also contribute to an increased risk. Based on recent research, there is a potential significant association between the incidence of preeclampsia and eclampsia and seasonal changes [6].

The results of this study indicate that based on body mass index and parity, almost all respondents (89%) were classified as having a high BMI and more than half of the respondents (52%) were primiparous. Pregnant women with low BMI and normal BMI showed equally low risk of preeclampsia. The incidence of preeclampsia in pregnant women with low and normal BMI is likely influenced by other factors, such as maternal age and parity[19]. Aini (2023) reported similar findings, namely that women who were obese before pregnancy had a higher risk of developing preeclampsia compared to women with normal BMI[20] . According to Temesgen and Tesfay's findings, gravidity shows no meaningful correlation with hypertensive disorder prevalence during pregnancy. Nevertheless, nulliparous women appear to face elevated risks of pregnancy related complications, such as elevated blood pressure, when compared to parous women. Additional research demonstrates that primigravida women with preeclampsia outnumber those without the condition by a two-to-one ratio, with primigravida status conferring greater preeclampsia susceptibility than multigravida status[21] .

Hypertension during pregnancy can also be influenced by nutritional factors, as the Madurese people tend to prefer salty foods over other flavors. Anggraeni (2024) states that administering salted fish extract as a model for pregnancy hypertension has a significant impact on increasing blood pressure and affecting protein-levels[22] . The occurrence of preeclampsia is influenced by various factors, including parity, ethnicity, genetic factors, maternal age over 35 years, and systemic diseases such as hypertension, diabetes mellitus, chronic kidney disease, and endocrine disorders. In addition, environmental factors such as living at high altitudes, obesity, and multiple pregnancies also play a role in increasing the risk. Based on recent research, there is a possibility of a significant association between the occurrence of preeclampsia and eclampsia with seasonal changes[6] . This is supported by a study by Andarini (2019), which shows that the proportion of the sample with prehypertension and hypertension was dominated by the Madurese and mixed Javanese-Madurese ethnic groups. The Madurese are known for their preference for salty and savory foods, and salt consumption is one of

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

the contributing factors to hypertension[23]

During the dry season, most (76%) pregnant women at ANNA Medika Madura General Hospital did not experience hypertension, while a small proportion (24%) did. Conversely, during the rainy season, the proportion of hypertension cases in pregnancy was higher than during the dry season, at 33%. Statistical test results show a significant relationship between seasonal variations and the incidence of hypertension in pregnancy ($p = 0.024$). These results indicate that the incidence of hypertension in pregnancy differs significantly between the dry season and the rainy season. Several studies show that hypertension disorders in pregnancy follow seasonal patterns, which can be explained by environmental temperature and humidity[24] . Extreme weather conditions, such as heat waves, storms, hurricanes, blizzards, cyclones, and floods, are manifestations of climate change. One of the main characteristics of climate change is variations in environmental temperature. Blood pressure has been found to fluctuate seasonally, with higher values in cold environmental temperatures than in hot temperatures[2526]. Pathophysiologically exposure to cold temperatures increases the activity of the sympathetic nervous system, causing vasoconstriction and endothelial dysfunction, thereby contributing to an increase in blood pressure[27]. Endothelial dysfunction is associated with various forms of hypertension, partly mediated by proinflammatory cytokines. The process of intravascular inflammatory adaptation is associated with endothelial cell dysfunction. Leukocyte activation in the maternal circulation in preeclampsia is considered an extreme state, with tumor necrosis factor α (TNF-α) and IL-6 playing a role in oxidative stress in preeclampsia[28].

The mechanism of environmental temperature's effect on hypertension disorders in pregnancy is still not fully understood. Cold temperature exposure triggers peripheral blood vessel vasoconstriction alongside elevated heart rate and blood pressure via sympathetic nervous system and renin–angiotensin system activation . Furthermore, cold exposure elevates cardiovascular risk biomarkers inflammation, coagulation factors, oxidative stress, endothelial function, and cholesterol concentrations . Such physiological alterations heighten cardiovascular disease susceptibility and facilitate hypertension development during pregnancy. Hot temperatures, conversely, induce fluid and electrolyte depletion, augmented cutaneous blood flow, diminished preload, and hypotensive tendencies[29] . Prior investigations in non- pregnant populations have established connections between cold temperature exposure and both increased blood pressure and hypertension prevalence [30] [31]These observations align with the present study's findings from Anna Medika General Hospital concerning hypertension risk during pregnancy.

Environmental temperature is one of the important causes of hypertension in pregnancy, particularly preeclampsia and eclampsia. The effects of extreme temperatures can be two-way in different trimesters of pregnancy. Therefore, appropriate environmental temperature control is important for pregnant women to avoid potential risks of hypertension in pregnancy[32]. This study provides initial indications of the importance of temperature regulation in the management of hypertension during pregnancy . One of the most noticeable impacts of climate change is the increase in extreme temperatures, with a number of studies showing that exposure to extreme heat during pregnancy can increase the risk of serious complications in pregnant women, including preeclampsia, premature birth, low birth weight, and maternal and neonatal mortality[33] .

In general, the challenges posed by climate change cover various aspects, including environmental changes such as rising sea surface temperatures, extreme weather events, and changes in rainfall patterns, which collectively increase the frequency and intensity of natural disasters such as floods, landslides, droughts, and storms[34] . In addition to damaging the environment, climate change also impacts human health, including the health of mothers and fetuses during pregnancy[35] . Part et al. (2022) reported that exposure to extreme temperatures, both hot and cold, in early pregnancy significantly increases the risk of hypertensive disorders that endanger the mother and fetus, including preeclampsia, progression to eclampsia accompanied by seizures, and severe liver and hematological complications associated with preeclampsia, such as HELLP syndrome[24]. Exposure to heat waves in early pregnancy is also known to increase the risk of severe hypertensive disorders. Conversely, exposure to low temperatures in the late trimester tends to increase the risk of gestational hypertension, especially in the first trimester, and is associated with various pregnancy complications, infections, hearing impairment, and neonatal jaundice[36] . Research in Denmark reported results similar to those of Park et al., more precisely, gestational hypertension and preeclampsia demonstrated maximum risk levels for summer conceptions, with minimum risk occurring during late autumn and winter conception periods. For the subset of women experiencing early-onset preeclampsia, however, spring conceptions carried the highest risk, whereas fall conceptions presented the lowest risk profile.[37]

Another reason behind the increase in pregnancy induced hypertension and preeclampsia during winter may be the drop in temperature and its effect on blood vessel vasoconstriction[38] as well as a decrease in plasma vitamin D levels due to reduced sunlight exposure [24]. In line with different studies where the results show that the incidence of hypertension in pregnancy depends on environmental factors (i.e., humidity, temperature, vitamin D, etc.), and therefore, this is the reason why this disease is more common in certain periods, in this case, the winter or rainy season[24]. Contributing factors include inadequate cutaneous synthesis or dietary insufficiency. The former predominates among individuals with limited sun exposure—northern residents, those predominantly indoors, elderly populations, darker-skinned individuals, those wearing concealing garments, or

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

sunscreen users [39].

These discoveries emphasize the necessity for customized healthcare interventions and approaches addressing pregnancy-specific risks across diverse climatic conditions. Geographic variations in hypertension-related pregnancy outcomes may originate from physiological adaptations and adaptive capabilities operating at individual and community scales, encompassing environmental determinants (temperature, humidity, air quality), biological factors (vitamin D levels and infectious agents[40] , behavioral-social dimensions (physical activity patterns and nutritional practices), and healthcare access. Additional investigation into climate variability's relationship with conception timing-related hypertension in pregnancy could illuminate underlying mechanisms while supporting adaptive service development to guide optimal conception timing, ultimately reducing hypertension in pregnancy incidence and enhancing maternal-infant outcomes[15] .

CONCLUSION AND RECOMMENDATIONS

Seasonal changes are significantly associated with cases of hypertension during pregnancy, with higher case numbers during the rainy season compared to the dry season. These findings suggest that climatic factors may play a role in the development of hypertension during pregnancy. Given these findings, healthcare providers are encouraged to maintain optimal antenatal monitoring throughout the year not just during the rainy season as there are still many sociodemographic factors that may contribute to the onset of hypertension during pregnancy, particularly among pregnant women with risk factors for gestational hypertension. Strategies for the prevention, early detection, and management of hypertension in pregnancy need to be further optimized. Additionally, further research is recommended to explore the mechanisms underlying this association and to develop specific seasonal intervention strategies. Conduct routine antenatal monitoring throughout the year, while recommending further controlled studies to confirm the observed seasonal patterns and clarify the underlying mechanisms.

AUTHORS' CONTRIBUTIONS

Novi Anggraeni contributed to concept development, literature review, and the design of intellectual experiments. She also contributed to the drafting of the manuscript and its content. In addition, she participated in the final refinement of the manuscript.
Samsiah Mat and Andriyanto contributed to the design of the methodology and statistical analysis. They also participated in writing the statistical section and the discussion of this article.
Rohilatul Jannah and Siti Rochimatul Lailiyah focused on data collection and data analysis. They also contributed to the compilation and editing of the research results.
Moh. Lutfi, Vivin Wijiastutik, and Alis Nurdiana contributed to the design of the methodology and statistical analysis, as well as the literature review

CONFLICT OF INTEREST

"The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest."

FUNDING

This study did not receive a specific grant from a funding agency in the public, commercial, or nonprofit sector

ACKNOWLEDGMENTS

The authors would like to thank all those who provided useful suggestions and support in this study.

REFERENCES

1. Sjaus A, McKeen DM, George RB. Les troubles hypertensifs de la grossesse. Canadian Journal of Anesthesia. 2016;63(9):1075–97. doi:10.1007/s12630-016-0689-8 PubMed PMID: 27443376.
2. Naderi S, Tsai SA, Khandelwal A. Hypertensive Disorders of Pregnancy. Curr Atheroscler Rep. 2017;19(3):15. doi:10.1007/s11883-017-0648-z
3. Tavakolipoor S, Beigi M, Nekuei NS, Shafiei F. The Prevalence of Pregnancy Hypertensive Disorders and Their Related Factors in the Second and Third Level Hospitals Affiliated to Isfahan University of Medical Sciences, Isfahan, Iran. Journal of Midwifery & Reproductive Health. 2019;7(3):1726–31. doi:10.22038/jmrh.2019.32423.1353
4. Behrens I, Basit S, Lykke JA, Ranthe MF, Wohlfahrt J, Bundgaard H, et al. Association between hypertensive disorders of pregnancy and later risk of cardiomyopathy. JAMA Intern Med. 2016;315(10):1026–33. doi:doi:10.1001/jama.2016.1869
5. Basit S, Wohlfahrt J, Boyd HA. Pre-eclampsia and risk of dementia later in life: nationwide cohort study. The Bmj. 2018;363(4109):1–8. doi:doi: https://doi.org/10.1136/bmj.k4109
6. Shahgheibi S, Rezaie M, Kamangar TM, Zarea S, Yousefi SR. The Effect of Season on the Prevalence of Preeclampsia. J Clin Gynecol Obstet. 2016;5(3):81–4. doi:10.14740/jcgo408w

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

7. Yemane A, Teka H, Ahmed S, Temesgen H, Langen E. Gestational hypertension and progression towards preeclampsia in Northern Ethiopia: prospective cohort study. BMC Pregnancy Childbirth. 2021;21(1):1–8. doi:10.1186/s12884-021-03712-w PubMed PMID: 33784971.
8. Novia Rita Putri, Eka Fitri Amir TJ. Analisis Kadar Hemoglobin Pada Ibu Hamil Terhadap Kejadian Preeklamsia Di RS X. Jurnal Menara Medika 2023;6(1):38–44.
9. Terefe W, Getachew Y, Hiruye A, Derbew M, Haile Mariam D, Mammo D, et al. Patterns Of Hypertensive Disorders Of Pregnancy And Associ-Ated Factors At Debre Berhan Referral Hospital, North Shoa, Amhara Region. Ethiop Med J. 2015;53(2):57–65. PubMed PMID: 26591284
10. Asseffa NA, Demissie BW. Perinatal outcomes of hypertensive disorders in pregnancy at a referral hospital, Southern Ethiopia. PLoS One. 2019;14(2):1–10. doi:https://doi.org/10.1371/journal.pone.0213240
11. Syahadatina M, Santoso B, Triawanti, Rahardjo B, Aditiawarman, Harjanto, et al. Konsep Preeklamsia : Patomekanise Dan Pencegahan. 2021. 1–69 p.
12. Basu R, Sarovar V, Malig BJ. Association between high ambient temperature and risk of stillbirth in California. Am J Epidemiol. 2016;183(10):894–901. doi:10.1093/aje/kwv295
13. Auger N, Siemiatycki J, Bilodeau-Bertrand M, Healy-Profitós J, Kosatsky T. Ambient temperature and risk of preeclampsia: biased association? Paediatr Perinat Epidemiol. 2017;31(4):267–71. doi:https://doi.org/10.1111/ppe.12362
14. Arikah T, Budi T, Rahardjo W, Widodo S. Faktor Risiko Kejadian Hipertensi pada Ibu Hamil di Puskesmas Kramat Jati Jakarta Timur Tahun 2019. JPPKMI. 2020;1(2):115–24. Available from: https://journal.unnes.ac.id/sju/index.php/jppkmi
15. Xie Y, Mu Y, Chen P, Wang Y, Li X, Dai L, et al. Season of conception and risk of hypertensive disorder during pregnancy. BMC Pregnancy Childbirth. 2025;25(97):1–11. doi: 10.1186/s12884-025-07210-1
16. Janani F, Changaee F. Seasonal variation in the prevalence of preeclampsia. J Family Med Prim Care. 2018;6(4):766–9. doi:10.4103/jfmpc.jfmpc
17. Sopaheluwakan A, Radjab AF. Prediksi Musim Kemarau 2024 di Indonesia. Fatchiyah. Badan Meteorologi Klimatologi dan Geofisika, editor. Jakarta; 2024.
18. Fura ANAJ, Wiyono RUA, Indarto I. Kecenderungan dan Perubahan Hujan Ekstrem Harian di Pulau Madura. Jurnal Ilmu Lingkungan. 2020;18(1):89–96. doi:10.14710/jil.18.1.89-96
19. Nadiro AH, Subiastutik E, Sasmito L. Hubungan Indeks Massa Tubuh (IMT) Dengan Resiko Preeklamsia Pada Ibu Hamil Trimester III. Jember Maternal and Child Health Journal. 2024;1(2):76–81. doi:10.31290/jmch.v1i2.5049
20. Aini FN, Zuhriyatun F, Hapsari W. Indeks massa tubuh (IMT) dengan kejadian preeklampsia pada ibu hamil. Jurnal Sains Kebidanan. 2023;5(1):24–9. doi:DOI: 10.31983/jsk.v5i1.9696
21. Arwan B, Sriyanti R. Hubungan Status Gravida, Usia, BMI (Body Mass Index) dengan Kejadian Preeklampsia. Andalas Obstetrics And Gynecology Journal. 2020;4(1):13–21. doi:DOI: https://doi.org/10.25077/aoj.4.1.13-21.2020
22. Anggraeni N, Sulistyono A, Prabowo GI, Aditiawarman A. The effect of administering salted fish extract as a model of pregnancy hypertension in mus musculus balb-c strain through blood pressure and urinary protein measurements. Journal of Medicinal and Pharmaceutical Chemistry Research. 2024;6(12):1787–96. https://doi.org/10.48309/jmpcr.2024.450643.1175
23. Andarini S, Rahmawati W, Maulidiana AR, Ilmu D, Masyarakat K, Kedokteran F, et al. Hubungan Indeks Massa Tubuh , Asupan Lemak , dan Mikronutrisi , serta Aktivitas Fisik terhadap Tekanan Darah pada Wanita Usia Subur Relationship between Body Mass Index , Fat and Micronutrients Intake , and Physical Activity to. Jurnal Kedokteran Brawijaya. 2019;30(4):277–82. DOI: https://doi.org/10.21776/ub.jkb.2019.030.04.8
24. Tafl C. Seasonal change of the prevalence of hypertensive. Perinatal Journal. 2019;27(2):101–4. doi:10.2399/prn.19.0272008
25. Ebi KL, Vanos J, Baldwin JW, Bell JE, Hondula DM, Errett NA, et al. Extreme weather and climate change: population health and health system implications. Annu Rev Public Health. 2021;42(1):293–315.
26. Stergiou GS, Palatini P, Modesti PA, Asayama K, Asmar R, Bilo G, et al. Seasonal variation in blood pressure: Evidence, consensus and recommendations for clinical practice. Consensus statement by the European Society of Hypertension Working Group on Blood Pressure Monitoring and Cardiovascular Variability. J Hypertens. 2020;38(7):1235–43. DOI: 10.1097/HJH.0000000000002341
27. Lee HA, Park H. Diet-related risk factors for incident hypertension during an 11-year follow-up: The Korean genome epidemiology study. Nutrients. 2018 Aug 13;10(8). doi:10.3390/nu10081077 PubMed PMID: 30104485.
28. Braunthal S, Brateanu A. Hypertension in pregnancy : Pathophysiology and treatment. SAGE Open Med. 2019;7:1–15. doi:10.1177/2050312119843700

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

29. Stewart S, Keates AK, Redfern A, McMurray JJ V. Seasonal variations in cardiovascular disease. Nat Rev Cardiol. 2017;14(11):654–64. . DOI: 10.1038/nrcardio.2017.76
30. Zhao H, Jivraj S, Moody A. 'My blood pressure is low today, do you have the heating on?'The association between indoor temperature and blood pressure. J Hypertens. 2019;37(3):504–12. doi:DOI: 10.1097/HJH.0000000000001924
31. Cabrera SE, Mindell JS, Toledo M, Alvo M, Ferro CJ. Associations of blood pressure with geographical latitude, solar radiation, and ambient temperature: results from the Chilean Health Survey, 2009–2010. Am J Epidemiol. 2016;183(11):1071–3. doi:10.1093/aje/kww037
32. Mao Y, Gao Q, Zhang Y, Yue Y, Ruan T, Yang Y, et al. Associations between extreme temperature exposure and hypertensive disorders in pregnancy: a systematic review and meta-analysis. Hypertens Pregnancy. 2023;42(1). doi:10.1080/10641955.2023.2288586 PubMed PMID: 38053322.
33. Bekkar B, Pacheco S, Basu R, DeNicola N. Association of air pollution and heat exposure with preterm birth, low birth weight, and stillbirth in the US: a systematic review. JAMA Netw Open. 2020;3(6):1–13. doi:10.1001/jamanetworkopen.2020.8243
34. Padlilah R, Farahdiba I, Umami N. Penguatan Pengetahuan Kader Dalam Mendampingi Ibu Hamil Pada Situasi Bencana Yang Dipicu Perubahan Iklim. Borneo Community Health Service Journal. 2025;5(1):134–8. DOI: https://doi.org/10.35334/neotyce.v5i1.6301
35. Mahardhika ZM, Hapsari IM, Rajib RK. Urgensi reformasi hukum lingkungan terhadap perubahan iklim di indonesia. Jurnal Kebijakan Pembangunan. 2024;19(2):235–44. doi:DOI 10.47441/jkp.v19i2.376
36. Part C, le Roux J, Chersich M, Sawry S, Filippi V, Roos N, et al. Ambient temperature during pregnancy and risk of maternal hypertensive disorders: a time-to-event study in Johannesburg, South Africa. Environ Res. 2022;212:1–8. doi:https://doi.org/10.1016/j.envres.2022.113596
37. Thomsen CR, Milidou I, Henriksen TB, Uldbjerg N. Seasonal variation in the hypertensive disorders of pregnancy in Denmark. Acta Obstet Gynecol Scand. 2020;99:623–30. doi:10.1111/aogs.13786
38. Hinkosa L, Tamene A, Gebeyehu N. Risk factors associated with hypertensive disorders in pregnancy in Nekemte referral hospital , from July 2015 to June 2017 , Ethiopia : case-control study. BMC Pregnancy Childbirth. 2020;20(16):1–9. doi:https://doi.org/10.1186/s12884-019-2693-9
39. Mierzy EPC and R. Could Vitamin D Be Effective in Prevention of Preeclampsia ? Nutrients. 2021;13(3854):1–32. doi:https://doi.org/10.3390/nu13113854
40. Simmering JE, Polgreen LA, Cavanaugh JE, Erickson BA, Suneja M, Polgreen PM. Warmer Weather and the Risk for Urinary Tract Infections in Women. HHS Public Access. 2022;205(2):500–6. doi:10.1097/JU.0000000000001383.