J Korean Med Sci. 2025 Dec 1;40(46):e302
https://doi.org/10.3346/jkms.2025.40.e302
eISSN 1598-6357·pISSN 1011-8934

JKMS

Original Article
Obstetrics & Gynecology

Check for updates

Elevated Pre-Pregnancy Blood Pressure and the Risk of Adverse Pregnancy Outcomes: Evidence From a Nationwide Population-Based Study

Yun Ji Jung [1], **Taesu Kim** [2], **and Young-Han Kim** [1]

[1]Department of Obstetrics and Gynecology, Institute of Women's Medical Life Science, Yonsei University College of Medicine, Seoul, Korea
[2]Department of Statistics, Sungkyunkwan University, Seoul, Korea

OPEN ACCESS

Received: May 3, 2025
Accepted: Jun 9, 2025
Published online: Oct 22, 2025

Address for Correspondence:
Young-Han Kim, MD, PhD
Department of Obstetrics and Gynecology, Institute of Women's Medical Life Science, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemoon-gu, Seoul 03722, Korea.
Email: yhkim522@yuhs.ac

ORCID iDs
Yun Ji Jung
https://orcid.org/0000-0001-6615-6401
Taesu Kim
https://orcid.org/0009-0005-6334-6900
Young-Han Kim
https://orcid.org/0000-0003-0645-6028

Funding
This study was supported by a faculty research grant of Yonsei University College of Medicine (6-2023-0099).

ABSTRACT

Background: Pre-pregnancy blood pressure (BP) has gained attention as a potential predictor of adverse pregnancy outcomes. However, data on the impact of mildly elevated BP, particularly in women without overt hypertension, remain limited. In this study, we aimed to examine the association between pre-pregnancy BP and adverse pregnancy outcomes in women without a history of hypertension.
Methods: In this retrospective nationwide study, we included pregnant women with pre-pregnancy BP below 140/90 mmHg and no prior diagnosis of hypertension. Participants were categorized based on their pre-pregnancy BP into the normal BP (< 120/80 mmHg), elevated BP (120–129 and < 80 mmHg), and stage 1 hypertension (130–139 or 80–89 mmHg) groups. The following adverse pregnancy outcomes were recorded: preeclampsia, gestational diabetes, placental abruption, postpartum hemorrhage, preterm birth, and small or large for gestational age. Multivariable logistic regression was used to evaluate the associations between pre-pregnancy BP categories and adverse pregnancy outcomes.
Results: Among 298,433 women, 76.9% had normal BP, 8.7% had elevated BP, and 14.3% had stage 1 hypertension. The incidence of adverse outcomes significantly increased in groups with higher BP (normal BP, 24.8%; elevated BP, 27.1%, and stage 1 hypertension, 29.9%; $P < 0.001$). Compared to the normal BP group, adjusted odds ratios for adverse outcomes were 1.11 (95% confidence interval [CI], 1.07–1.14) for the elevated BP group and 1.24 (95% CI, 1.21–1.27) for the stage 1 hypertension group. A curvilinear relationship was observed between pre-pregnancy BP and the risk of adverse pregnancy outcomes.
Conclusion: Even modest increases in pre-pregnancy BP below the clinical threshold for hypertension were associated with a higher risk of adverse pregnancy outcomes. These findings highlight the need for early BP monitoring and management before pregnancy.

Keywords: Blood Pressure; Preconception Care; Pregnancy; Pregnancy Complications

Disclosure
The authors have no potential conflicts of interest to disclose.

Data Availability Statement
The datasets collected and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions
Conceptualization: Jung YJ, Kim YH. Data curation: Jung YJ. Formal analysis: Jung YJ, Kim T. Investigation: Jung YJ, Kim T. Methodology: Jung YJ, Kim YH, Kim T. Software: Jung YJ, Kim T. Validation: Jung YJ, Kim T. Visualization: Jung YJ, Kim T. Writing - original draft: Jung YJ. Writing - review & editing: Jung YJ, Kim YH.

INTRODUCTION

Pregnancy-induced hypertension is a common complication of pregnancy that is associated with significant maternal and neonatal morbidity, such as preeclampsia, placental abruption, preterm birth, intrauterine growth restriction, and an increased risk of maternal cardiovascular disease.[1,2] The incidence of gestational hypertension and preeclampsia has steadily increased with the increasing number of pregnancies resulting from in vitro fertilization and among women with pre-existing medical conditions.[3,4]

Although numerous studies have explored the clinical risk factors associated with hypertension during pregnancy, most women are not initially classified as high-risk before developing preeclampsia, and effective preventive strategies remain limited.[1] Pre-pregnancy blood pressure (BP) has been associated with an increased risk of preeclampsia, particularly in cases with overt hypertension presenting before pregnancy.[5,6] However, this association has rarely been examined, especially in low-risk women with pre-pregnancy BP in the borderline range below the diagnostic threshold for hypertension.[7]

Recent research has highlighted the importance of pre-pregnancy BP, even in low-risk populations. Among healthy women, small increases in BP during the preconception period and early pregnancy are associated with a significant increase in the risk of preeclampsia.[8] Moreover, pre-pregnancy BP has been linked to an increased risk of metabolic diseases during pregnancy. Women with elevated BP before or during early pregnancy are reportedly at higher risk of developing gestational diabetes mellitus (GDM).[9,10] Abnormal maternal pre-pregnancy BP has also been associated with an increased risk of preterm birth, thereby highlighting the importance of early detection and appropriate management of abnormal BP before pregnancy.[11]

Considering the growing evidence linking pre-pregnancy BP to adverse pregnancy outcomes, in this study, we aimed to determine the association between categorized pre-pregnancy BP and adverse pregnancy outcomes in a large population-based cohort of Korean women.

METHODS

Study population

In this retrospective nationwide study, we used data obtained from the Korean Health Insurance Review and Assessment database. This database collects claims data from the single-payer National Health Insurance Service, which covers 97% of the population. Under this system, all subscribers are required to participate in the biannual National Health Screening Examination (NHSE) at no charge.

We identified all women with singleton deliveries in South Korea who delivered between January 1, 2015, and December 31, 2021, and included those who underwent the NHSE within 6 months before pregnancy and participated in the national health screening program for infants and children after delivery. Women with a diagnosis of chronic hypertension, use of antihypertensive medications, as identified in the NHSE, pre-pregnancy systolic BP (SBP) ≥ 140 mmHg or diastolic BP (DBP) ≥ 90 mmHg, multifetal pregnancies, or missing data were excluded from our analysis. Other comorbidities, including pre-pregnancy diabetes and rheumatic diseases, were not included in the exclusion criteria. However, pre-pregnancy

diabetes was adjusted for as a covariate in the multivariable models to control for potential confounding.

Assessment of adverse pregnancy outcomes

The NHSE health examination included measurements of pre-pregnancy BP, pre-pregnancy body mass index (BMI, kg/m^2), and laboratory parameters. BP was measured in the seated position using semi-automated sphygmomanometers, after at least 5 minutes of rest, in accordance with standardized protocols recommended by international guidelines.[12] Blood samples were collected after at least 8 hours of fasting, and fasting glucose, total cholesterol, aspartate aminotransferase (AST), and alanine aminotransferase (ALT) levels were analyzed.

Women were classified into three pre-pregnancy BP groups according to the American College of Cardiology (ACC)/American Heart Association (AHA) guidelines[12]: normal BP (SBP < 120 mmHg and DBP < 80 mmHg), elevated BP (SBP 120–129 mmHg and DBP < 80 mmHg), and stage 1 hypertension (SBP 130–139 mmHg or DBP 80–89 mmHg).

The primary outcome was the incidence of adverse pregnancy outcomes, defined as the presence of one or more obstetric complications. The International Classification of Diseases, 10th revision was used to identify the following complications: preeclampsia, GDM, placental abruption, placenta previa, and postpartum hemorrhage. Preterm birth was defined as delivery before 37 completed weeks of gestation. Small for gestational age (SGA) and large for gestational age (LGA) were defined as birth weights below the 10th percentile and above the 90th percentile of gestational age, respectively.

Statistical analysis

Continuous variables are described as means and standard deviations and were compared using Student's *t*-test or an analysis of variance model for multiple group comparisons. Categorical variables are presented as numbers and percentages and were compared using the χ^2 test.

Multivariate logistic regression analysis was performed to estimate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for adverse pregnancy outcomes according to the pre-pregnancy BP categories. Models were adjusted for maternal age, pre-pregnancy BMI, fasting glucose, liver enzymes (AST and ALT), total cholesterol, and pregestational diabetes. For exploratory purposes, the relationships between pre-pregnancy BP and adverse pregnancy outcomes were also assessed using restricted cubic splines. Statistical analyses were performed using SAS for Windows, version 9.4 (SAS Inc., Cary, NC, USA) software, and *P* values < 0.05 were considered statistically significant.

Ethics statement

This study was approved by the Institutional Review Board (IRB) of Severance Hospital (IRB No. 4-2025-0301). The requirement for informed consent was waived because of the retrospective nature of the study and the use of anonymized data.

RESULTS

Of 474,200 women screened, we excluded 3,906 women with pre-existing hypertension, 5,732 with pre-pregnancy SBP ≥ 140 mmHg or DBP ≥ 90 mmHg at the time of the health examination, and 166,129 with missing data. The final cohort comprised 298,433 participants (**Fig. 1**).

https://doi.org/10.3346/jkms.2025.40.e302

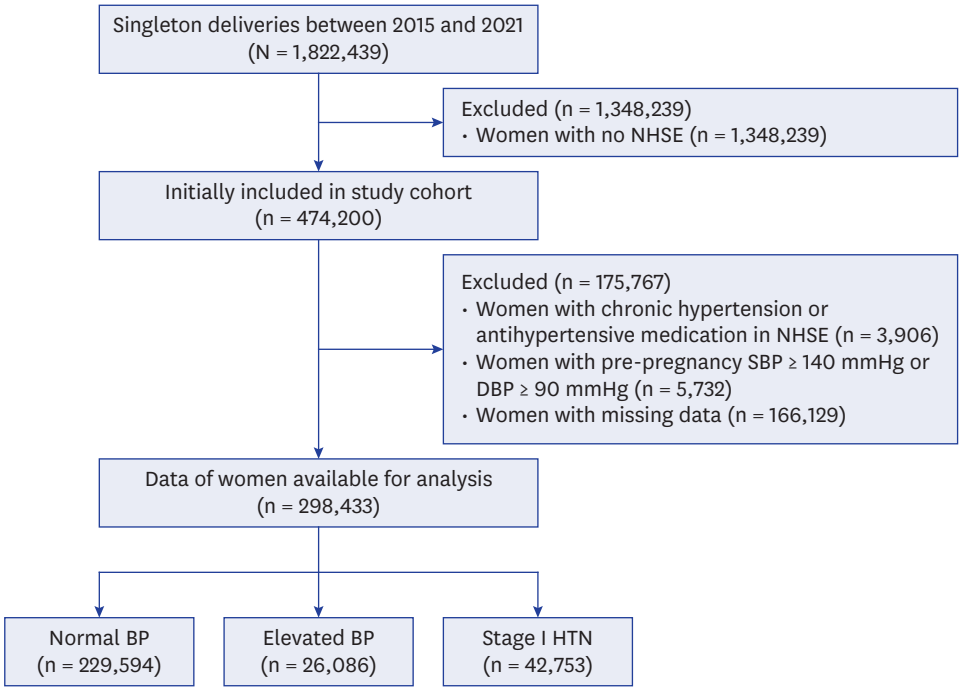

Fig. 1. Flowchart of the study selection.
NHSE = National Health Screening Examination, SBP = systolic blood pressure, DBP = diastolic blood pressure, BP = blood pressure, HTN = hypertension.

Table 1 shows the baseline characteristics of the study population, which was categorized into the normal BP (SBP < 120 mmHg and DBP < 80 mmHg, N = 229,594; 76.9%), elevated BP (SBP 120–129 mmHg and DBP < 80 mmHg, n = 26,086; 8.7%), and stage 1 hypertension (SBP 130–139 mmHg or DBP 80–89 mmHg, n = 42,753; 14.3%) groups. Maternal age, prevalence of pregestational diabetes, pre-pregnancy BMI, and both pre-pregnancy SBP and DBP were positively associated with increased pre-pregnancy BP (all $P < 0.001$). Preconception laboratory examinations such as fasting glucose, total cholesterol, and liver enzyme levels (AST and ALT) also increased significantly with higher pre-pregnancy BP (all $P < 0.001$). Notably, fasting glucose and total cholesterol levels demonstrated a stepwise increase across the groups, suggesting a graded metabolic risk profile associated with

Table 1. Baseline characteristics according to pre-pregnancy BP

Variables	Normal BP (N = 229,594)	Elevated BP (n = 26,086)	Stage 1 HTN (n = 42,753)	*P* value[a]
Maternal age, yr	32.70 ± 3.97	32.86 ± 4.21	33.10 ± 4.28	< 0.001***
Pregestational DM	2,255 (1.0)	341 (1.3)	768 (1.8)	< 0.001***
Pre-pregnancy BMI, kg/m^2	21.04 ± 2.72	22.36 ± 3.45	22.77 ± 3.94	< 0.001***
Fasting glucose, mg/dL	66.37 ± 6.29	72.09 ± 4.58	81.08 ± 3.85	< 0.001***
Total cholesterol, mg/dL	179.86 ± 30.94	183.60 ± 31.42	185.69 ± 31.88	< 0.001***
AST, IU/L	19.05 ± 12.13	19.64 ± 9.72	20.28 ± 11.74	< 0.001***
ALT, IU/L	14.78 ± 13.97	16.32 ± 15.16	17.63 ± 51.33	< 0.001***
Pre-pregnancy SBP, mmHg	106.01 ± 7.76	122.66 ± 2.60	123.18 ± 8.16	< 0.001***
Pre-pregnancy DBP, mmHg	66.32 ± 6.20	72.05 ± 4.60	81.13 ± 3.92	< 0.001***

Values are presented as mean ± standard deviation or number (%).
BP = blood pressure, HTN = hypertension, DM = diabetes mellitus, BMI = body mass index, AST = aspartate aminotransferase, ALT = alanine aminotransferase, SBP = systolic blood pressure, DBP = diastolic blood pressure.
[a]Differences among the three pre-pregnancy BP categories.
***$P < 0.001$.

https://doi.org/10.3346/jkms.2025.40.e302

Table 2. Pregnancy and neonatal outcomes according to pre-pregnancy BP

Variables	Normal BP (N = 229,594)	Elevated BP (n = 26,086)	Stage 1 HTN (n = 42,753)	*P* value[a]
Adverse pregnancy outcome	56,878 (24.8)	7,059 (27.1)	12,760 (29.9)	< 0.001***
Preeclampsia	5,386 (2.4)	877 (3.4)	1,956 (4.6)	< 0.001***
Gestational diabetes mellitus	16,987 (7.4)	2,477 (9.5)	4,741 (11.1)	< 0.001***
Placenta previa	4,867 (2.1)	542 (2.1)	857 (2.0)	0.124
Placental abruption	968 (0.4)	116 (0.4)	191 (0.5)	0.409
Postpartum hemorrhage	25,874 (11.3)	2,860 (11.0)	4,902 (11.5)	0.487
Preterm birth	5,725 (2.5)	788 (3.0)	1,405 (3.3)	< 0.001***
Gestational age at delivery, wk	39.60 ± 1.45	39.50 ± 1.48	39.46 ± 1.56	< 0.001***
Male baby	118,244 (51.5)	13,456 (51.6)	21,924 (51.3)	0.543
Birthweight, kg	3.25 ± 4.87	3.26 ± 6.09	3.30 ± 8.38	0.292
Small for gestational age	34,154 (14.9)	3,852 (14.8)	6,635 (15.5)	0.002**
Large for gestational age	15,095 (6.6)	1,984 (7.6)	3,369 (7.9)	< 0.001***

Values are presented as mean ± standard deviation or number (%).
BP = blood pressure, HTN = hypertension.
[a]Differences among the three pre-pregnancy BP groups.
**P < 0.01, ***P < 0.001.

elevated pre-pregnancy BP. Pairwise comparisons of baseline characteristics are provided in **Supplementary Table 1**, showing consistent trends across all group pairs.

Adverse pregnancy outcomes increased significantly with higher pre-pregnancy BP (24.8% in the normal BP group vs. 27.1% in the elevated BP group vs. 29.9% in the stage 1 hypertension group; P < 0.001; **Table 2**). Specifically, the incidence of preeclampsia, GDM, preterm birth, and LGA increased significantly across all groups (all P < 0.001). The prevalence of SGA increased modestly but significantly (P = 0.002). No significant differences were observed in the rates of placenta previa, placental abruption, postpartum hemorrhage, neonatal sex, or birth weight. To further support these findings, **Supplementary Table 2** presents pairwise comparisons of adverse pregnancy outcomes. Although certain comparisons revealed additional statistically significant differences, they did not alter the overall interpretation of the results.

The adjusted ORs for adverse pregnancy outcomes and each obstetric complication according to the pre-pregnancy BP categories are shown in **Table 3** and **Fig. 2**. Both elevated BP and stage 1 hypertension were associated with an increased risk of adverse pregnancy outcomes (OR, 1.11; 95% CI, 1.07–1.14 and OR, 1.24; 95% CI, 1.21–1.27, respectively). Stage 1 hypertension increased the risk of preeclampsia (OR, 1.68; 95% CI, 1.62–1.75), GDM (OR, 1.13; 95% CI, 1.09–1.17), preterm birth (OR, 1.20; 95% CI, 1.15–1.24), and SGA (OR, 1.22; 95% CI, 1.17–1.27) compared with normal BP. Compared with normal BP, elevated

Table 3. Association between obstetric outcomes and pre-pregnancy BP

Variables	Normal BP (N = 229,594)	Elevated BP (n = 26,086)	Stage 1 HTN (n = 42,753)
Adverse pregnancy outcome	1 (reference)	1.105 (1.073–1.138)	1.241 (1.213–1.271)
Gestational DM	1 (reference)	1.068 (1.020–1.118)	1.131 (1.091–1.173)
Preeclampsia	1 (reference)	1.285 (1.194–1.383)	1.684 (1.594–1.779)
Preterm birth	1 (reference)	1.142 (1.058–1.233)	1.198 (1.127–1.274)
Small for gestational age	1 (reference)	1.113 (1.073–1.154)	1.218 (1.183–1.254)
Large for gestational age	1 (reference)	0.929 (0.883–0.976)	0.865 (0.830–0.902)
Placental abruption	1 (reference)	1.065 (0.876–1.293)	1.071 (0.913–1.255)
Placenta previa	1 (reference)	0.972 (0.888–1.064)	0.916 (0.850–0.988)
Postpartum hemorrhage	1 (reference)	0.964 (0.925–1.005)	1.013 (0.980–1.047)

Values are presented as odds ratios adjusted for maternal age, pre-pregnancy body mass index, fasting glucose, aspartate aminotransferase, alanine aminotransferase, total cholesterol, and pregestational DM (95% confidence intervals). The normal BP group was used as the reference.
BP = blood pressure, HTN = hypertension, DM = diabetes mellitus.

https://doi.org/10.3346/jkms.2025.40.e302

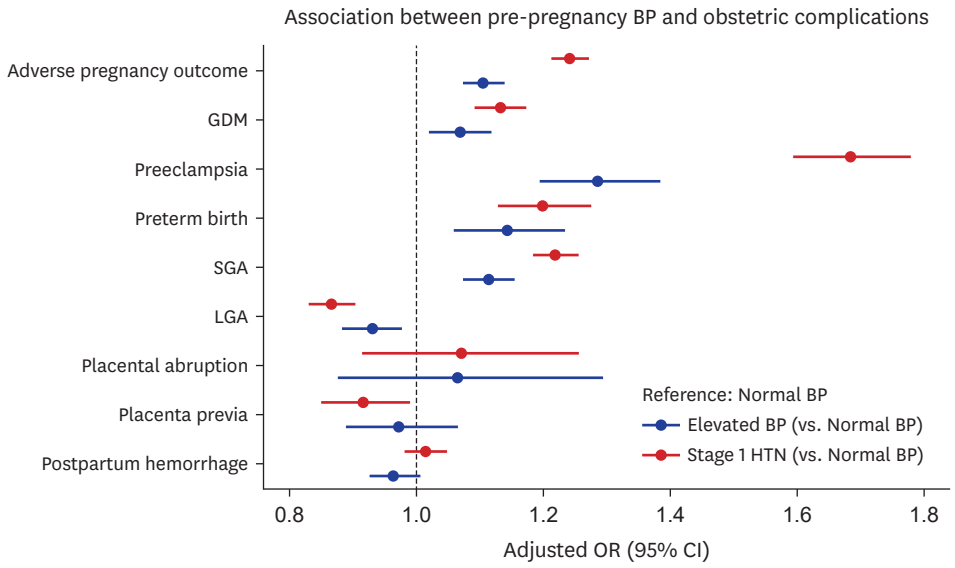

Fig. 2. Forest plot showing associations between pre-pregnancy BP and adverse pregnancy outcomes. Adjusted ORs and 95% CIs for various obstetric complications were estimated using multivariate logistic regression. The normal BP group was used as the reference. The models were adjusted for maternal age, pre-pregnancy BMI, fasting glucose, AST, ALT, total cholesterol, and pregestational diabetes. The normal blood pressure group was used as the reference.
BP = blood pressure, OR = odds ratio, CI = confidence interval, BMI = body mass index, AST = aspartate aminotransferase, ALT = alanine aminotransferase, GDM = gestational diabetes mellitus, SGA = small for gestational age, LGA = large for gestational age, HTN = hypertension.

BP also increased the risks of preeclampsia (OR, 1.34; 95% CI, 1.28–1.41), GDM (OR, 1.11; 95% CI, 1.06–1.16), preterm birth (OR, 1.10; 95% CI, 1.05–1.15), and SGA (OR, 1.11; 95% CI, 1.06–1.17). No significant associations were observed for postpartum hemorrhage or placental abruption, whereas the risk of LGA slightly decreased in both the elevated BP and stage 1 hypertension groups. The risk of placenta previa showed a modest decrease, slightly lower in the stage 1 hypertension group. The association between pre-pregnancy BP and obstetric complications was the most pronounced for preeclampsia and preterm birth, with the highest odds observed in the stage 1 hypertension group.

Elevated pre-pregnancy BP was significantly associated with a higher risk of adverse pregnancy outcomes, particularly preeclampsia, GDM, preterm birth, and SGA. A curvilinear relationship between pre-pregnancy BP and the risk of adverse outcomes was observed across both SBP and DBP (**Fig. 3**). These relationships remained robust after adjusting for relevant covariates. Detailed restricted cubic spline models illustrating the association between pre-pregnancy BP and individual outcomes are presented in **Supplementary Figs. 1** and **2**.

DISCUSSION

In this large, nationwide population-based study, we determined the association between pre-pregnancy BP and adverse pregnancy outcomes. We found that borderline elevated pre-pregnancy BP and stage 1 hypertension defined according to the ACC/AHA guidelines[12] were significantly associated with an increased risk of adverse pregnancy outcomes, preeclampsia, GDM, preterm birth, and SGA. A curvilinear dose-response relationship was observed, reinforcing the clinical relevance of pre-pregnancy BP screening and management.

https://doi.org/10.3346/jkms.2025.40.e302

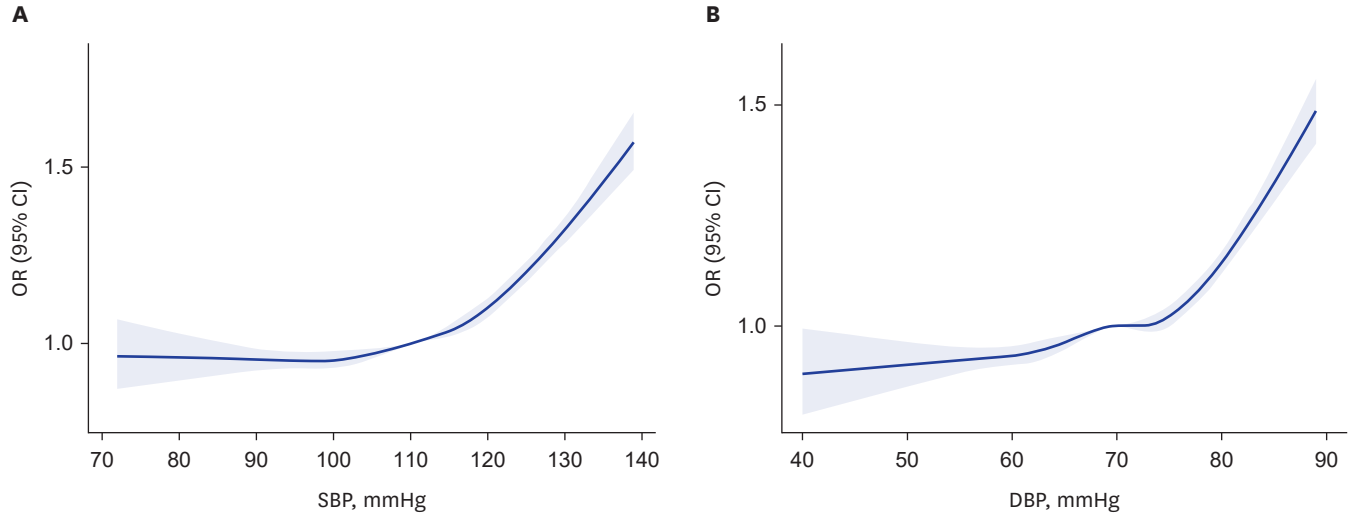

Fig. 3. Non-linear association between pre-pregnancy blood pressure and adverse pregnancy outcomes. Restricted cubic spline plots showing the relationship between pre-pregnancy (**A**) SBP and (**B**) DBP with the risk of adverse pregnancy outcomes. Models were adjusted for maternal age, pre-pregnancy body mass index, fasting glucose, liver enzymes (aspartate aminotransferase and alanine aminotransferase), total cholesterol, and pregestational diabetes.
SBP = systolic blood pressure, DBP = diastolic blood pressure, OR = odds ratio, CI = confidence interval.

The American College of Obstetrics and Gynecologists (ACOG) currently defines hypertensive disorders of pregnancy as BP ≥ 140/90 mmHg and does not explicitly recommend clinical management for pre-pregnancy BP below this threshold.[13] However, considering the evidence that cardiovascular risks increase even below the traditional threshold of 140/90 mmHg, the ACC/AHA lowered the diagnostic criteria for hypertension to ≥ 130/80 mmHg in 2017.[12,14] Previous studies have indicated that using these lower diagnostic thresholds of BP significantly improves the identification of women at risk for preeclampsia, preterm birth, and adverse perinatal outcomes.[15-17]

With increasing maternal age and associated complications, such as hypertension, the importance of preconception care has become more evident, as emphasized by the World Health Organization in its definition of comprehensive health interventions before conception to improve maternal and neonatal outcomes.[18] Although BP during pregnancy has traditionally been the primary focus, recent studies have indicated pre-pregnancy BP as a key predictor of adverse pregnancy outcomes.[8,19-22] A recent large-scale study by Xiong et al.[7] demonstrated that pre-pregnancy elevated BP or hypertension is associated with a higher risk of adverse pregnancy outcomes, including preterm birth, SGA, and perinatal infant death. Additionally, a nationwide Korean study by Jung et al.[6] reported that pre-pregnancy stage 1 hypertension was associated with an increased risk of maternal and neonatal complications, such as preeclampsia and preterm birth. This study showed a linear association between pre-pregnancy BP and composite morbidity, with risk peaking at newly defined stage 1 hypertension and decreasing at lower BP ranges.[6]

While previous studies primarily focus on overt hypertension, our results further demonstrated that even modest elevations in pre-pregnancy BP, specifically elevated BP (SBP 120–129 mmHg and DBP < 80 mmHg) and stage 1 hypertension (SBP 130–139 mmHg or DBP 80–89 mmHg) categorized based on the ACC/AHA guidelines,[12] are significantly associated with increased risks of preeclampsia, preterm birth, GDM, and SGA. In light of the ongoing debate, our findings support a more proactive approach: although there is no existing consensus on the treatment of elevated BP or stage 1 hypertension before or during

https://doi.org/10.3346/jkms.2025.40.e302

pregnancy, early recognition and intervention of elevated pre-pregnancy BP may provide opportunities for improved pregnancy outcomes.

Our study has several notable strengths. First, the use of a large, nationwide, population-representative dataset ensured a robust statistical power and enhanced the generalizability of the findings. By using information from the government-funded, bi-annual NHSE program, we could obtain reliable pre-pregnancy BP data and assess their association with adverse pregnancy outcomes in a large cohort of reproductive-age women, an otherwise difficult task given that young women are often not routinely screened for BP. Furthermore, we applied a refined classification of pre-pregnancy BP, enabling detailed comparisons between normotensive and hypertensive women, as well as among those with borderline elevated BP who did not meet the diagnostic criteria for clinical hypertension. This classification enabled the detection of increased risks within the borderline BP range, highlighting the clinical importance of early BP monitoring and intervention in women of reproductive age.

Despite these strengths, our study has some limitations. First, its retrospective observational design limited the ability to draw definitive causal inferences between pre-pregnancy BP and adverse pregnancy outcomes. Second, participation in the NHSE program is voluntary; as women who underwent such screenings could differ systematically from the general population, this limitation might have introduced a selection bias and might affect the generalizability of our findings. Third, data on essential lifestyle factors, such as diet, physical activity, and smoking, as well as underlying medical conditions, such as cardiovascular, autoimmune, and renal diseases, were unavailable. The absence of these variables may have led to residual confounding factors. Finally, pre-pregnancy BP was measured only once at rest during the NHSE; thus, the potential for measurement variability or overestimation cannot be excluded. Future studies should use a prospective design that examines the association between longitudinal changes in BP from the preconception period through pregnancy and subsequent pregnancy outcomes.

In conclusion, our findings indicated that both stage 1 hypertension and mildly elevated pre-pregnancy BP, traditionally considered within the normal range, significantly increases the risk of adverse pregnancy outcomes. These findings highlight the need to revisit and possibly redefine BP management thresholds in obstetric practice. Our findings also underscored the importance of routine BP assessment during the preconception period to optimize maternal and neonatal health outcomes.

ACKNOWLEDGMENTS

We would like to thank Editage (www.editage.co.kr) for English language editing.

SUPPLEMENTARY MATERIALS

Supplementary Table 1
Baseline characteristics according to pre-pregnancy BP

Supplementary Table 2
Pregnancy and neonatal outcomes according to pre-pregnancy BP

Supplementary Fig. 1

Curvilinear dose-response relationships between pre-pregnancy SBP and adverse pregnancy outcomes. Each panel presents the adjusted dose-response relationship between SBP (mmHg) and the risk of adverse pregnancy outcomes, modeled using restricted cubic splines. Adjustments were made for maternal age, pre-pregnancy body mass index, fasting glucose, aspartate aminotransferase, alanine aminotransferase, total cholesterol, and pregestational diabetes. The solid line represents the estimated association, and the shaded area indicates the 95% CIs.

Supplementary Fig. 2

Curvilinear dose-response relationships between pre-pregnancy DBP and adverse pregnancy outcomes. Each panel depicts the association between DBP (mmHg) and adverse pregnancy outcomes, using logistic regression with restricted cubic splines and adjusting for the same covariates. Solid lines show estimated ORs; shaded areas represent 95% CIs.

REFERENCES

1. Gestational hypertension and preeclampsia: ACOG practice bulletin, number 222. *Obstet Gynecol* 2020;135(6):e237-60. PUBMED | CROSSREF
2. Magee LA, Pels A, Helewa M, Rey E, von Dadelszen P; Canadian Hypertensive Disorders of Pregnancy (HDP) Working Group. Diagnosis, evaluation, and management of the hypertensive disorders of pregnancy. *Pregnancy Hypertens* 2014;4(2):105-45. PUBMED | CROSSREF
3. Gui J, Ling Z, Hou X, Fan Y, Xie K, Shen R. In vitro fertilization is associated with the onset and progression of preeclampsia. *Placenta* 2020;89:50-7. PUBMED | CROSSREF
4. Wright D, Syngelaki A, Akolekar R, Poon LC, Nicolaides KH. Competing risks model in screening for preeclampsia by maternal characteristics and medical history. *Am J Obstet Gynecol* 2015;213(1):62.e1-62.e10. PUBMED | CROSSREF
5. Ardissino M, Slob EAW, Millar O, Reddy RK, Lazzari L, Patel KHK, et al. Maternal hypertension increases risk of preeclampsia and low fetal birthweight: genetic evidence from a Mendelian randomization study. *Hypertension* 2022;79(3):588-98. PUBMED | CROSSREF
6. Jung YM, Oh GC, Noh E, Lee HY, Oh MJ, Park JS, et al. Pre-pregnancy blood pressure and pregnancy outcomes: a nationwide population-based study. *BMC Pregnancy Childbirth* 2022;22(1):226. PUBMED | CROSSREF
7. Xiong W, Han L, Tang X, Wang Q, Chen W, Li R, et al. Preconception blood pressure and adverse pregnancy outcomes: a population-based cohort study. *Hypertension* 2024;81(4):e31-40. PUBMED | CROSSREF
8. Nobles CJ, Mendola P, Mumford SL, Silver RM, Kim K, Andriessen VC, et al. Preconception blood pressure and its change into early pregnancy: early risk factors for preeclampsia and gestational hypertension. *Hypertension* 2020;76(3):922-9. PUBMED
9. Hedderson MM, Ferrara A. High blood pressure before and during early pregnancy is associated with an increased risk of gestational diabetes mellitus. *Diabetes Care* 2008;31(12):2362-7. PUBMED | CROSSREF
10. Leon MG, Moussa HN, Longo M, Pedroza C, Haidar ZA, Mendez-Figueroa H, et al. Rate of gestational diabetes mellitus and pregnancy outcomes in patients with chronic hypertension. *Am J Perinatol* 2016;33(8):745-50. PUBMED | CROSSREF
11. Xiong W, Han L, Tang X, Wang Q, Chen W, Li R, et al. Association of maternal preconception blood pressure with preterm birth: a population-based cohort study. *Hypertens Res* 2024;47(2):467-77. PUBMED | CROSSREF
12. Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *J Am Coll Cardiol* 2018;71(19):e127-248. PUBMED | CROSSREF
13. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics. ACOG practice bulletin No. 203: chronic hypertension in pregnancy. *Obstet Gynecol* 2019;133(1):e26-50. PUBMED | CROSSREF

14. SPRINT Research Group, Wright JT Jr, Williamson JD, Whelton PK, Snyder JK, Sink KM, et al. A randomized trial of intensive versus standard blood-pressure control. *N Engl J Med* 2015;373(22):2103-16. PUBMED | CROSSREF
15. Bello NA, Zhou H, Cheetham TC, Miller E, Getahun DT, Fassett MJ, et al. Prevalence of hypertension among pregnant women when using the 2017 American College of Cardiology/American Heart Association blood pressure Guidelines and association with maternal and fetal outcomes. *JAMA Netw Open* 2021;4(3):e213808. PUBMED | CROSSREF
16. Slade LJ, Mistry HD, Bone JN, Wilson M, Blackman M, Syeda N, et al. American College of Cardiology and American Heart Association blood pressure categories-a systematic review of the relationship with adverse pregnancy outcomes in the first half of pregnancy. *Am J Obstet Gynecol* 2023;228(4):418-429.e34. PUBMED | CROSSREF
17. Sutton EF, Hauspurg A, Caritis SN, Powers RW, Catov JM. Maternal outcomes associated with lower range stage 1 hypertension. *Obstet Gynecol* 2018;132(4):843-9. PUBMED | CROSSREF
18. Preconception care: maximizing the gains for maternal and child health-policy brief. https://www.who.int/publications/i/item/WHO-FWC-MCA-13.02. Updated 2013. Accessed November 4, 2023.
19. Yang Y, He Y, Li Q, Wang Y, Peng Z, Xu J, et al. Preconception blood pressure and risk of preterm birth: a large historical cohort study in a Chinese rural population. *Fertil Steril* 2015;104(1):124-30. PUBMED | CROSSREF
20. Nobles CJ, Mendola P, Mumford SL, Naimi AI, Yeung EH, Kim K, et al. Preconception blood pressure levels and reproductive outcomes in a prospective cohort of women attempting pregnancy. *Hypertension* 2018;71(5):904-10. PUBMED | CROSSREF
21. Jin M, Liu X, Liu X, Wu Y, Zhang Y, Zhang L, et al. Association of pre-/early pregnancy high blood pressure and pregnancy outcomes: a systemic review and meta-analysis. *J Matern Fetal Neonatal Med* 2024;37(1):2296366. PUBMED | CROSSREF
22. Hong X, Zhao J, Huang K, Dai Q, Zhang H, Xuan Y, et al. Preconception blood pressure and time to pregnancy among couples attempting to conceive their first pregnancy. *Am J Obstet Gynecol* 2019;221(5):470.e1-470.e10. PUBMED | CROSSREF