

# Postpartum Outcomes With Systematic Treatment and Management of Postpartum Hypertension

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**OBJECTIVE:** To test the ability of a hospital-wide, bundled quality-improvement initiative to improve postpartum maternal blood pressure control and adherence to postpartum follow-up among patients with hypertensive disorders of pregnancy.

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*This quality improvement project is supported by the Department of Obstetrics and Gynecology at the University of Chicago, University of Chicago Women's Board, Chicago Lying-in Board of Directors at the University of Chicago and Preeclampsia Foundation.*

*Presented at the Illinois Perinatal Quality Collaborative's annual meeting, November 4, 2019, Lombard, Illinois. Abstract accepted for presentation at the 2020 ACOG Annual Clinical and Scientific Meeting. Presented at the University of Chicago Medicine's 15<sup>th</sup> Annual Quality and Safety Symposium, held virtually, October 19–23, 2020.*

*The authors thank all obstetric and emergency department nurses, our patients, faculty, trainees, and staff at University of Chicago Medical Center for their participation in this initiative. We would like to acknowledge OMRON for providing blood pressure monitors in kind and at subsidized rates. OMRON did not fund any part of the study and played no part in study design, analysis or article preparation.*

*Each author has confirmed compliance with the journal's requirements for authorship.*

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## Financial Disclosure

*Ariel Mueller reports receiving funding as a statistical consultant for University of Chicago and Roche Diagnostics. Avery Tung reports receiving funding from Anesthesia & Analgesia (editorial work for journal). S. Rana reports serving as a consultant for Roche Diagnostics, and ThermoFisher and has received research funding from Roche Diagnostics and Siemens for work related to angiogenic biomarkers. The other authors did not report any potential conflicts of interest.*

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ISSN: 0029-7844/21

**METHODS:** This quality-improvement initiative consisted of a bundle of clinical interventions including health care professional and patient education, a dedicated nurse educator, and protocols for postpartum hypertensive disorders of pregnancy care in the inpatient, outpatient and readmission setting. We implemented this initiative in patients with hypertensive disorders of pregnancy starting in January 2019 at the University of Chicago. The study period was divided into four periods, which correspond to preintervention, distinct bundle roll outs, and postintervention. Our primary outcome was postpartum hypertension visit adherence. Secondary outcomes included blood pressure values and antihypertensive medication use in the immediate postpartum and outpatient postpartum time periods. We then stratified our outcomes by race to assess whether the effect size differed.

**RESULTS:** A total of 926 patients who delivered between September 2018 and November 2019 were included. Postpartum hypertension visit adherence improved from preintervention period compared with the full implementation period (33.5% vs 59.4%,  $P<.001$ ). Blood pressure in the first 24 hours postpartum decreased from preintervention compared with full implementation (preintervention median [interquartile range] systolic blood pressure 149 mm Hg [138, 159] vs 137 [131, 146] in postimplementation;  $P<.001$ ). After implementation, fewer patients experienced a blood pressure of 140/90 mm Hg or higher at the first postpartum blood pressure check, when compared with preintervention (39.1% vs 18.5%,  $P=.004$ ). The effect size did not differ by race.

**CONCLUSION:** A bundled quality-improvement initiative for patients with hypertensive disorders of pregnancy was associated with improved postpartum visit adherence and blood pressure control in the postpartum period.

(*Obstet Gynecol* 2021;138:777–87)

DOI: 10.1097/AOG.0000000000004574



**H**ypertensive disorders of pregnancy affect approximately 10% of all pregnant women in the United States.<sup>1</sup> Within the first 6 weeks after delivery, hypertensive disorders of pregnancy and related morbidities are a common cause of readmission.<sup>2</sup> In the first year after delivery, women with an hypertensive disorders of pregnancy have 12- to 25-fold higher rates of postpartum hypertension than women with a normotensive pregnancy.<sup>3</sup> In addition, in Black women, hypertensive disorders of pregnancy are more common and result in greater morbidity such as mortality and stroke.<sup>4-7</sup> There is little specific guidance or standardization in regards to postpartum management of hypertension in pregnancy.

Existing care strategies for hypertensive disorders of pregnancy focus on management of severe hypertension, including medications, discharge instructions, and close follow-up after delivery.<sup>1</sup> Although control of blood pressure in the postpartum period is associated with reduced cardiovascular disease among women, follow-up compliance is poor.<sup>7</sup> A 2018 American College of Obstetricians and Gynecologists Practice Bulletin suggested that up to 40% of women will not attend a postpartum visit.<sup>8</sup> This gap in health care delivery also exacerbates racial disparities, because Black women have an even lower likelihood of attending a postpartum follow-up visit than White women.<sup>9</sup> Few studies have focused on system-level initiatives to improve postpartum care for women with hypertensive disorders of pregnancy to reduce associated adverse outcomes. Although there are some studies on new interventions, such as telehealth, to improve postpartum care and reduce racial disparities, standardization of practice in the postpartum period has not been adequately studied.<sup>10,11</sup>

To address the lack of standardization of care among women with hypertensive disorders of pregnancy, we developed and implemented a quality-improvement initiative to improve postpartum care of women with hypertensive disorders of pregnancy (STAMPP HTN [Systematic Treatment And Management of PostPartum Hypertension]) at the University of Chicago, an urban tertiary care center with a predominantly Black and publicly insured population. The bundle incorporated strict inpatient and outpatient protocols, workflows, health care practitioner education, and a dedicated patient nurse educator. The objective of this study was to evaluate the performance of this bundled initiative with respect to adherence to recommended postpartum follow-up visits. The secondary objective was to determine whether the bundle was associated with improved blood pressure management and control in the immediate postpartum and outpatient

postpartum period. We also examined the effect size of our initiatives by race and insurance type.

## METHODS

The STAMPP HTN bundle was created and implemented as a series of interventions at a tertiary care hospital to address hypertensive disorders of pregnancy postpartum in both the inpatient and outpatient setting. Before development and implementation, all postpartum patients received similar follow up care and no specific protocols or pathway existed for patients with hypertensive disorders of pregnancy.

Table 1 shows the study interventions based on the needs assessment and protocols and workflows are shown in Appendices 1–7, available online at <http://links.lww.com/AOG/C455>. Patient education materials were certified by our institution to aim for an eighth grade reading level. Patients with hypertensive disorders of pregnancy were given appointments before discharge verbally and in writing at the University of Chicago for postpartum hypertension follow-up, regardless of primary obstetrician. Protocols were created based on prior evidence, guidelines, and expert consensus opinion of the maternal–fetal medicine group at our hospital, as well as a cardiologist. Implementation of the STAMPP HTN bundle was approved as a quality-improvement initiative by the University of Chicago. Subsequent retrospective medical record abstraction over the period specified was approved with a waiver of informed consent by the University of Chicago Institutional Review Board (#IRB20-1167).

The STAMPP HTN bundle was applied to all women with any hypertensive disorder of pregnancy, which included preeclampsia with or without severe features, gestational hypertension, chronic hypertension, or chronic hypertension with superimposed preeclampsia, who delivered at the University of Chicago Medical Center from January 2019 onward. For this analysis, data were collected from September 2018 through November 2019. Patients with a diagnosis of hypertensive disorders of pregnancy in the antepartum or intrapartum period were included for analysis. Definitions of hypertension were based on the American College of Obstetricians and Gynecologists guidelines, namely using a systolic blood pressure of 140–160 or a diastolic of 90–110 for diagnosis of hypertension and a blood pressure greater than 160 systolic or 110 diastolic for severe hypertension (Appendix 1, <http://links.lww.com/AOG/C455>).<sup>1</sup>

The analysis was divided into four time periods: 1) September 2018–December 2018 as the preintervention period (baseline control period with no bundle interventions); 2) January 2019–June 2019 as the patient-level intervention period (protocol including patient



**Table 1. Problems Identified in the Care of Women With Hypertensive Disorders of Pregnancy and the Solutions as Part of the Systematic Treatment and Management of Postpartum Hypertension Bundle**

Problem	STAMPP HTN Bundle
Problems and needs identified at the level of the hospital	
At the time of admission and discharge	
Need for comprehensive knowledge among nursing, residents, physicians, midlevel providers	Grand rounds, lunch and learn, annual competency
Lack of standardized patient counseling regarding long-term effects of preeclampsia	Creation of the video for patients ( <a href="https://www.youtube.com/watch?v=hVPxFZDEFZI">https://www.youtube.com/watch?v=hVPxFZDEFZI</a> ) Preeclampsia instruction sheet (Appendix 1, <a href="http://links.lww.com/AOG/C455">http://links.lww.com/AOG/C455</a> )
No organized effort for education including discharge instructions to patients	Education to patients during admission by dedicated nurse educator
PP blood pressure check scheduling by patients	Nurse educator scheduling and informing patient of PP appointment before discharge
Limited access to BP monitors at home	Provision of free BP monitors to all patients before discharge
No protocols or pathways for management of PPHTN after delivery	Creation of inpatient and outpatient protocols for management of PPHTN (Appendices 2–4, <a href="http://links.lww.com/AOG/C455">http://links.lww.com/AOG/C455</a> )
Problems with readmissions in the ED	
Identifying postpartum patients in the ED	Creation of pathways and workflows (Appendix 5, <a href="http://links.lww.com/AOG/C455">http://links.lww.com/AOG/C455</a> )
Poor nonobstetric physician adherence and knowledge of PPHTN management	Creation of protocols for ED and education of all ED physicians using online annual competency module
Nonobstetric service consultation for management of postpartum hypertension	Protocol for readmissions
Delayed transfer to labor and delivery	Creation of pathways and workflows (Appendices 5 and 6, <a href="http://links.lww.com/AOG/C455">http://links.lww.com/AOG/C455</a> )
Delay in recognition and treatment of severe PPHTN	Creation of pathways and workflows (Appendices 5 and 6, <a href="http://links.lww.com/AOG/C455">http://links.lww.com/AOG/C455</a> )
Readmissions for PPHTN	
No specific recommendation for readmissions	Creation of protocols for readmissions (Appendices 5 and 6, <a href="http://links.lww.com/AOG/C455">http://links.lww.com/AOG/C455</a> )
Follow-up of patients after discharge	
Postpartum patients dispersed in various different clinics and with limited time slots	Creation of accessible PPHTN clinic specially designed for these patients
Wide variation in management of postpartum hypertension in the outpatient setting	Creation of protocols for management of BP and medication adjustments in outpatient clinics by maternal–fetal medicine and cardiology specialists (Appendix 4, <a href="http://links.lww.com/AOG/C455">http://links.lww.com/AOG/C455</a> )
Lack of documented counseling for patients about risk of long-term risk of HDP for cardiovascular disease at postpartum visit	Standardized education in PPHTN clinic. Follow-up appointment recommended with primary care or cardiology within 6 mo

STAMPP HTN, Systematic Treatment And Management of PostPartum Hypertension; PPHTN, postpartum hypertension; ED, emergency department; HDP, hypertensive disorders of pregnancy.

educational material, video, and patient discharge checklist rolled out); 3) July 2019–September 2019 as the final stage of the intervention, which included a dedicated nurse educator for education and scheduling of postpartum visits; and 4) October 2019–November

2019 as following full implementation. These time periods were selected because they corresponded to distinct roll out periods of the study interventions (Appendix 7, <http://links.lww.com/AOG/C455>). Formal education regarding the bundle was provided to all



health care professionals, including residents, fellows, nurses, midwives, and attending physicians.

Study data were abstracted from the medical record by trained nurses and research staff on a standardized data collection form. Data collection included baseline demographics, antepartum, intrapartum characteristics, delivery information, antihypertensive medication use, postpartum maternal outcomes, postpartum inpatient and outpatient blood pressure, and the number and timing of postpartum visits. Visits were classified as either postpartum hypertension-related or as the standard 6-week postpartum visit based on the medical record. All data were entered in REDCap (Research Electronic Data Capture) database. Data were collected up to 6 weeks postpartum. As part of our protocol, all patients were instructed to return to the University of Chicago for their postpartum visits related to their hypertensive disorder. Therefore, adherence data were solely collected from the University of Chicago medical system.

The primary outcome was attendance of any postpartum hypertension appointment up to 6 weeks postpartum. Secondary outcomes included maternal blood pressure values and use of antihypertensive medication in the inpatient and outpatient postpartum period at varying time points including first 24 hours in-hospital postpartum, in hospital time period from delivery to discharge, hypertensive postpartum visit, and final 6-week visit. Analyses were repeated by race and insurance type to assess the effect variation. A Breslow-Day test was used to assess the homogeneity of odds ratios by race. Readmission rates to the University of Chicago were also calculated in each time period.

Normality of continuous variables was assessed with a Shapiro-Wilk test. Nonnormal continuous variables are presented as median (interquartile range) and analyzed using either a Wilcoxon rank sum or Kruskal-Wallis test. Categorical data are presented as frequencies and proportions and assessed for differences with  $\chi^2$  tests. Univariable and multivariable logistic regression was used to evaluate postpartum visit attendance across the intervention time periods. Multivariable models were adjusted for clinically significant variables, which included age, race, diagnosis, insurance type, mode of delivery, and registration for prenatal care. A two-sided  $P < .05$  was used to indicate statistical significance for all analyses using SAS 9.4. For ease of reporting, estimates and  $P$ -values are reported for all time periods in the tables, but only proportions for preintervention, and after full implementation are reported in the text. Statistical tests and all  $P$ -values are reported assessing for differences all four time periods unless otherwise stated. No a priori power calculation was performed.

## RESULTS

A total of 926 women with hypertensive disorders of pregnancy delivered across the time periods, with 197 patients in the preintervention period, 334 patients in the patient-level intervention period, 239 patients in the nurse-educator intervention period, and 155 patients after full implementation. Overall, the median age of patients was 28 years (interquartile range 24, 33), 65.7% of patients were publicly insured, and 79.9% were Black. Patients most commonly had either preeclampsia with or without severe features (50.9%) or gestational hypertension (36.7%); 12.4% patients had chronic hypertension.

Demographic characteristics were compared across the four time periods in Table 2. Race, ethnicity, smoking status, delivery gestational age, preexisting diabetes, nulliparity, and postpartum length of stay did not differ across time periods. The proportion of patients with Medicaid insurance decreased across the time periods (72.1% preimplementation vs 57.4% after full implementation,  $P = .004$ ). The proportion of patients with a previous diagnosis of preeclampsia trended down through the study period (10.2% preimplementation vs 5.2% after full implementation,  $P = .09$ ).

Our primary outcome of attendance at postpartum hypertension visits before 6 weeks postpartum increased considerably throughout the follow-up period (33.5% in preintervention vs 59.4% in post-full intervention,  $P < .001$ ; Fig. 1A). The greatest incremental increase in the proportion of patients who returned for a postpartum hypertension visit was from before to after the hiring of a dedicated nurse educator (38.3% patient-level intervention vs 56.1% in nurse educator intervention;  $P < .001$ ). In a multivariable model adjusted for age, race, diagnosis, insurance type, mode of delivery, and registration for prenatal care, the association between STAMPP HTN bundle use and attendance at postpartum hypertension visits remained robust; individual adjusted odds ratio (aOR) (95% CI) for each time period using preimplementation as the referent (patient-level intervention: aOR 1.16, 95% CI 0.78–1.72; nurse educator intervention: aOR 2.78, 95% CI 1.82–4.26; full implementation: aOR 2.82, 95% CI 1.78–4.46). Median time to follow-up among patients who returned for a postpartum hypertension visit was 10 (interquartile range 8, 13) days. Most patients who attended a follow-up appointment, did so in the first 3 weeks postpartum. Attendance at the 6-week postpartum visit, likewise, increased in all patients across the period (33.2% preimplementation vs 47.7% after full implementation,  $P = .01$ ; Fig. 1B).

Characteristics associated with patients across all time points who did and did not follow up within 6 weeks are displayed in Table 3. Those who did not follow



**Table 2. Characteristics of Patients Stratified by Period\***

Characteristic	September–December 2018 (Preintervention) (n=197)	January–June 2019 (Patient-Level Intervention) (n=334)	July–September 2019 (Nurse Educator Intervention) (n=239)	October–November 2019 (Post-Full Implementation) (n=155)	P
Demographic characteristics					
Age (y)	26 (22, 32)	29 (24, 34)	29 (24, 34)	29 (25, 33)	.001
BMI at delivery (kg/m <sup>2</sup> )	33.8 (27.5, 41.02)	34.5 (29.9, 40.24)	34.4 (30.3, 40.2)	34.3 (28.4, 41.2)	.22
Public insurance	142 (72.1)	216 (64.7)	162 (67.8)	89 (57.4)	.03
Race					
Asian	3 (1.5)	10 (3.0)	5 (2.1)	2 (1.3)	.13
Black	160 (81.2)	263 (78.7)	195 (81.6)	122 (78.7)	
Multiracial	2 (1.0)	8 (2.4)	7 (2.9)	7 (4.5)	
Native Hawaiian/Other Pacific Islander	1 (0.5)	0 (0)	0 (0)	0 (0)	
Unknown or not reported	3 (1.5)	13 (3.9)	0 (0)	3 (1.9)	
White	28 (14.2)	40 (12.0)	32 (13.4)	21 (13.6)	
Hispanic or Latina	13 (6.6)	15 (4.5)	12 (5.0)	10 (6.5)	.54
Registered for prenatal care	186 (94.4)	321 (96.1)	198 (82.9)	150 (96.8)	<.001
Primary obstetrician at the study hospital	81 (41.1)	170 (50.9)	133 (55.7)	90 (58.1)	.01
Nulliparous	106 (53.8)	171 (51.2)	118 (49.4)	89 (57.4)	.42
Current smoker	9 (4.9)	24 (7.5)	14 (6.1)	11 (7.4)	.68
Gestational diabetes	13 (6.6)	21 (6.3)	23 (9.6)	10 (6.5)	.43
Pre-existing diabetes	10 (5.1)	20 (6.0)	18 (7.5)	11 (7.1)	.73
Preeclampsia in previous pregnancy	20 (10.2)	18 (5.4)	30 (12.6)	8 (5.2)	.01
Cardiac disease	1 (0.5)	8 (2.4)	3 (1.3)	8 (5.2)	.02
Antepartum or labor and delivery characteristics					
Fetal growth restriction	26 (13.2)	38 (11.4)	25 (10.5)	15 (9.7)	.73
Antepartum antihypertensive use	62 (31.5)	105 (31.4)	75 (31.4)	48 (31.0)	.99
Antepartum magnesium	75 (38.1)	108 (32.3)	73 (30.5)	51 (32.9)	.39
Diagnosis					
Gestational hypertension	76 (39.4)	130 (38.9)	71 (30.0)	60 (38.7)	.003
Preeclampsia	88 (45.6)	124 (37.1)	106 (44.7)	49 (31.6)	
Superimposed preeclampsia	21 (10.9)	33 (9.9)	27 (11.4)	20 (12.9)	
Chronic hypertension	8 (4.2)	47 (14.1)	33 (13.9)	26 (16.8)	
Severe features	71 (36.0)	113 (33.8)	81 (34.2)	53 (34.2)	.96
Gestational age at delivery (wk)	38.4 (36.3, 39.4)	38.4 (37.0, 39.4)	38.1 (37.0, 39.4)	38.4 (37.0, 39.6)	.90
Mode of delivery					
Cesarean	71 (36.0)	103 (30.8)	79 (33.1)	61 (39.4)	.03
Estimated blood loss (mL)	431 (225, 742)	378 (200, 673)	420 (255, 717)	450 (251, 940)	.04
Postpartum hemorrhage	54 (27.4)	69 (20.7)	57 (23.9)	43 (27.7)	.21
Disseminated intravascular coagulation	1 (0.5)	1 (0.3)	0 (0)	0 (0)	.63
Abruption	4 (2.0)	5 (1.5)	3 (1.3)	1 (0.7)	.74
Thromboembolic disease	2 (1.0)	0 (0)	0 (0)	0 (0)	.06
Intensive care unit admission	3 (1.5)	4 (1.2)	1 (0.4)	1 (0.7)	.63
Length of stay (d)	4 (3, 5)	4 (3, 5)	4 (3, 4)	4 (3, 4)	.86

BMI, body mass index.

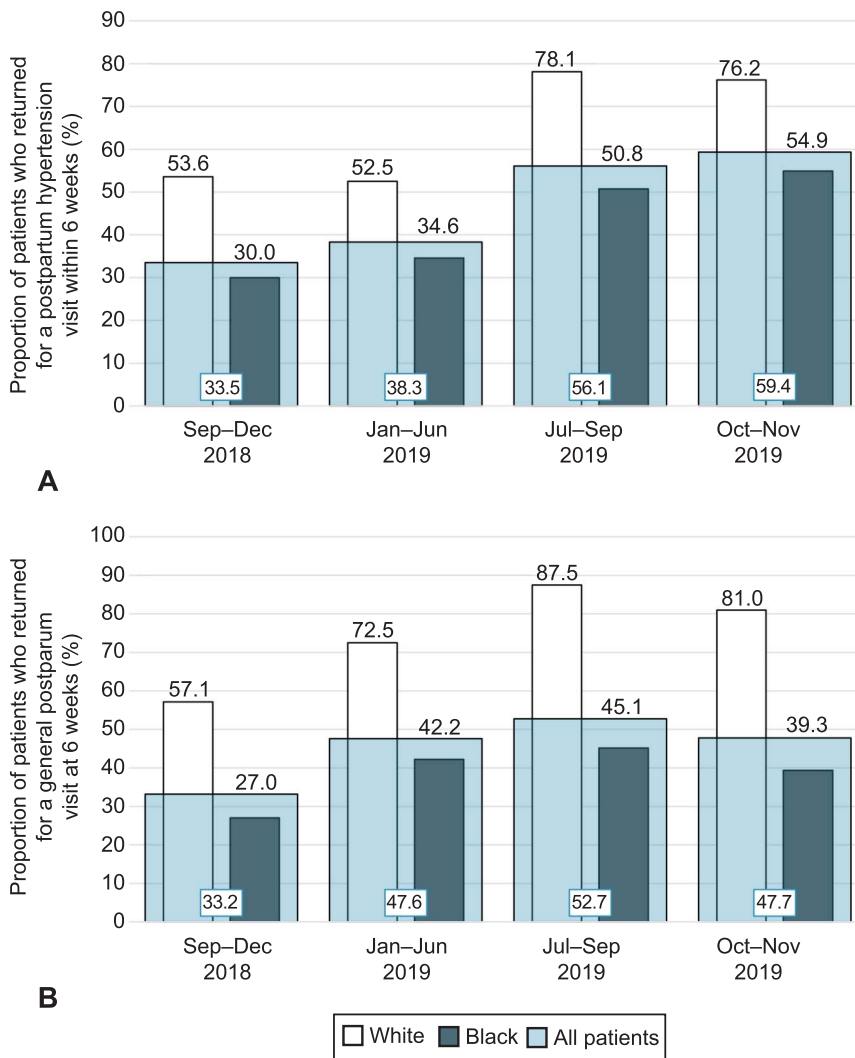
Data are median (quartile 1, quartile 3) or n (%) unless otherwise specified.

\* One patient delivered in December of 2019 and is therefore excluded from this table.

up within 6 weeks were younger, more likely to be Black, and more likely to have public insurance. Patients who presented for a 6-week follow-up were more likely to have their primary obstetrician at the University of Chi-

cago, be registered anywhere for prenatal care, have gestational diabetes, and have a diagnosis of chronic hypertension. Demographic characteristics of patients who did not follow-up in the full implementation time





**Fig. 1.** Postpartum visit adherence. **A.** The primary outcome of adherence to postpartum hypertension visits across time. The proportion of patients who came back for a blood pressure check increased across time (33.5% vs 59.4%,  $P < .001$ ). **B.** Adherence to general postpartum visit at 6 weeks. The proportion of patients who came back for a postpartum visit(s) at 6 weeks increased across the periods (33.2% vs 47.7%,  $P = .01$ ), with improvements for both White and Black patients.

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period were analyzed in a post hoc analysis and were notable for a higher prevalence of public insurance (Appendix 8, available online at <http://links.lww.com/AOG/C455>).

The postpartum bundle incorporated guidelines for inpatient postpartum blood pressure management while maintaining previous standards for treatment of hypertensive urgency (Appendices 2 and 3, <http://links.lww.com/AOG/C455>). In the immediate inpatient postpartum period, defined as within 24 hours after delivery, the percentage of patients with elevated (140/90 or higher) blood pressure decreased across study periods (Fig. 2A). Blood pressure in the first 24 hours postpartum decreased across the time periods (preintervention [interquartile range] systolic blood pressure 149 mm Hg [138, 159] vs 137 [131, 146] after full implementation;  $P < .001$ ). The prevalence of severe hypertension in the first 24

hours postpartum decreased after full implementation in comparison with preintervention (3.2% vs 28.4%,  $P < .001$ ). After full implementation, 34.8% of patients had blood pressure of 140/90 or higher at discharge, compared with 45.7% preimplementation ( $P = .04$ , Fig. 2B). In the period between delivery and discharge, the proportion of patients with severe hypertension (above 160/110) decreased (Fig. 2C preimplementation 32.0% vs after full implementation 7.1%,  $P < .001$ ). Use of antihypertensive medications across the periods was similar (31.5% preimplementation vs 29.7% after full implementation,  $P = .72$ ); however, we did not examine the medication dose or the time frame in which medications were prescribed.

Systolic blood pressure at the time of the first postpartum hypertension visit decreased after bundle implementation (129 mm Hg [interquartile range 122,



**Table 3. Characteristics of Patients With and Without Postpartum Hypertension Follow-up**

Characteristic	Entire Cohort (N=926)	No Postpartum Follow-up Within 6 wk (n=506)	Postpartum Follow-up Within 6 wk (n=420)	P
Demographic or clinical characteristics				
Age (y)	28 (24, 33)	27 (22, 32)	30 (25, 34)	<.001
BMI at delivery (kg/m <sup>2</sup> )	34.4 (29.3, 40.3)	33.8 (28.8, 40.1)	35.0 (30.0, 40.6)	.03
Public insurance	609 (65.8)	400 (79.1)	209 (49.8)	<.001
Race				
Asian	20 (2.2)	7 (1.4)	13 (3.1)	<.001
Black	740 (80.0)	435 (86.0)	305 (72.6)	
Multiracial	24 (2.6)	8 (1.6)	16 (3.8)	
Native Hawaiian/Other Pacific Islander	1 (0.1)	0 (0)	1 (0.2)	
Unknown or not reported	20 (2.2)	12 (2.4)	8 (1.9)	
White	121 (13.1)	44 (8.7)	77 (18.3)	
Hispanic or Latina	50 (5.4)	20 (4.0)	30 (7.1)	.10
Registered for prenatal care	856 (92.4)	457 (90.3)	399 (95.)	.01
Primary obstetrician at the study hospital	475 (51.3)	185 (36.6)	290 (69.1)	<.001
Nulliparous	485 (52.4)	233 (46.1)	252 (60.0)	<.001
Gestational diabetes	67 (7.2)	22 (4.4)	45 (10.7)	<.001
Current smoker	58 (6.6)	42 (9.0)	16 (3.9)	.002
Preeclampsia in previous pregnancy	76 (8.2)	44 (8.7)	32 (7.6)	.55
Preexisting diabetes	59 (6.4)	27 (5.3)	32 (7.6)	.16
Cardiac disease	20 (2.2)	10 (2.0)	10 (2.4)	.67
Antepartum or delivery characteristics				
Fetal growth restriction	104 (11.2)	53 (10.5)	51 (12.1)	.42
Antepartum antihypertension use	291 (31.4)	139 (27.5)	152 (36.2)	.004
Antepartum magnesium	307 (33.2)	153 (30.2)	154 (36.7)	.04
Diagnosis				
Gestational hypertension	338 (36.7)	205 (40.8)	133 (31.8)	.001
Preeclampsia	367 (39.9)	201 (40.0)	166 (39.7)	
Superimposed preeclampsia	101 (11.0)	39 (7.8)	62 (14.8)	
Chronic hypertension	114 (12.4)	57 (11.4)	57 (13.6)	
Severe features	318 (34.4)	157 (31.1)	161 (38.4)	.02
Gestational age at delivery (wk)	38.4 (37.0, 39.4)	38.6 (37.0, 39.6)	38.1 (36.6, 39.3)	.005
NICU admission	285 (30.8)	142 (28.1)	143 (34.1)	.049
Type of labor				
Induced	548 (59.2)	280 (55.3)	268 (63.8)	<.001
Spontaneous	260 (28.1)	174 (34.4)	86 (20.5)	
Nonlaboring	118 (12.7)	52 (10.3)	66 (15.7)	
Mode of delivery				
Cesarean	314 (33.9)	159 (31.4)	155 (36.9)	.22
Postpartum antihypertension use	281 (30.4)	139 (27.5)	142 (33.8)	.04

BMI, body mass index; NICU, neonatal intensive care unit.

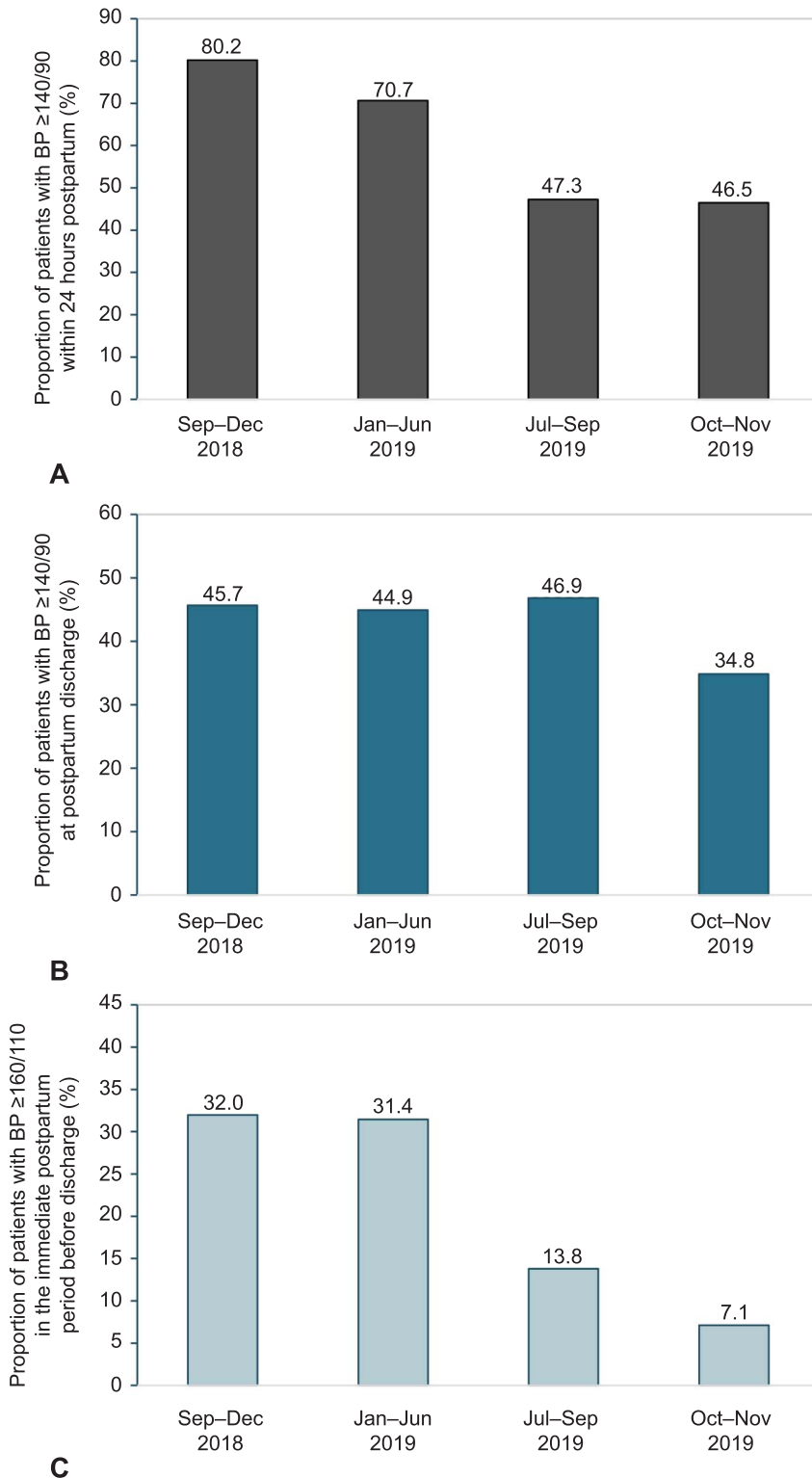
Data are median (quartile 1, quartile 3) or n (%) unless otherwise specified.

136] after full implementation vs 136 mm Hg [interquartile range 128, 143] in preimplementation,  $P=.002$ , Appendix 9, available online at <http://links.lww.com/AOG/C455>). The percentage of patients with a blood pressure of 140/90 mm Hg or higher in the first postpartum hypertensive visit also decreased over the study period both for patients with gestational hypertension and preeclampsia (15.3% after full implementation vs 35.9% preimplementation,  $P=.01$ ) and overall (18.5% after full implementation, vs 39.1% preimplementation,  $P=.004$ ; Fig. 3A). The incidence of severe hypertension

at the first postpartum visit (defined as blood pressure 160/110 or higher) did not differ (0% in preimplementation vs 2.17% after full implementation,  $P=.51$ ). The percentage of patients with a blood pressure of 140/90 mm Hg or higher at the standard 6-week visit was not statistically significantly different across the time periods (Fig. 3B).

We examined the rate of all-cause readmission across the time periods, including emergency department visits. We found that the rates of all-cause readmission were 4.6% in preimplementation,





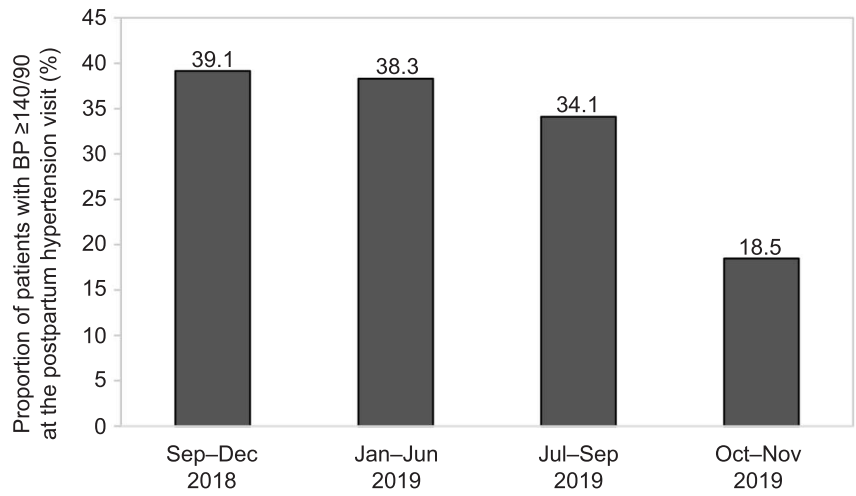
**Fig. 2.** Immediate blood pressure across time periods. This figure shows the secondary outcome of postpartum blood pressure immediately postpartum and before discharge. **A and B.** Proportion of patients with hypertension in the first 24 hours immediately postpartum and at the time closest to hospital discharge, respectively. **C.** Patients with severe hypertension in the immediate postpartum period after delivery but before discharge. Suresh. *Systematic Treatment and Management of Postpartum HTN. Obstet Gynecol* 2021.

9.9% patient-level intervention, 9.2% nurse educator intervention, and 16.1% after full intervention ( $P=.004$ ). When looking at rate of hypertension-

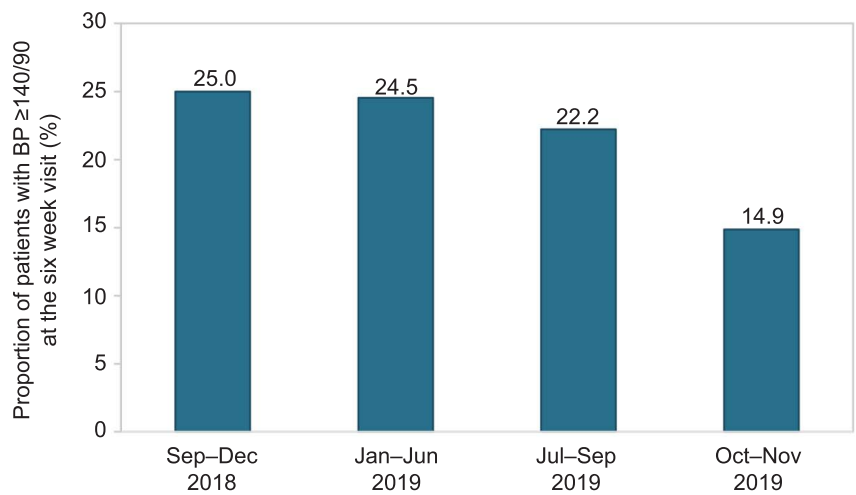
related readmission (defined as postpartum headache, chest pain or shortness of breath, preeclampsia, and elevated blood pressure), we found no







**A**



**B**

**Fig. 3.** Proportion of patients with elevated blood pressure at follow-up visits. **A.** At the first postpartum follow-up, a lower number of patients experienced postpartum hypertension at the later time periods as compared with the first (18.5% vs 39.1%;  $P=.004$ ). **B.** At the general postpartum visit, the incidence of hypertension was reduced but not significantly different between the last and first period (14.9% vs 25.0%;  $P=.13$ )

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statistical difference across the study time periods (4.1%; 7.5%; 8.4%; 9.0%;  $P=.24$ ).

The absolute increase in adherence for a postpartum hypertension visit was similar between Black and non-Black women (24.9% vs 22.6% respectively,  $P=.97$ ; Fig. 1A). The absolute increase in adherence for the 6-week postpartum visit was also similar (23.8% vs 12.3% respectively,  $P=.41$ ; Fig. 1B). A Breslow-Day test for the homogeneity of odds ratios by race demonstrated no significant difference ( $P=.97$ ), indicating that the effect size of our intervention did not differ by race. After full implementation, we found that there was still a substantial disparity in postpartum visit adherence between Black and non-Black women (54.9% vs 76.2%,  $P=.03$ ).

A post hoc analysis of patients with public insurance was performed to assess the association between the STAMPP HTN bundle implementation

and attendance at a postpartum hypertension visit. The proportion of patients who returned for a postpartum hypertension visit significantly increased in both groups (26.1% preimplementation vs 43.8% after full implementation;  $P=.01$  for public insurance and 52.7% preimplementation vs 80.3% after full implementation for private insurance;  $P=.001$ ).

## DISCUSSION

We found that a bundled postpartum hypertension initiative targeting postpartum visit adherence, improved health care professional workflow, and strict blood pressure goals in women with hypertensive disorders of pregnancy improved maternal outcomes including increased adherence to postpartum hypertension visits, and decreased blood pressure both in the inpatient and outpatient postpartum setting. We found this initiative had similar effect size



regardless of race and insurance type and, therefore, did not eliminate disparities.

Prior work has described the effect of hypertensive disorders of pregnancy on both short-term and long-term maternal morbidity including stroke, eclampsia, renal disease, liver disease, and long-term cardiovascular disease.<sup>3,12,13</sup> A prior toolkit aimed at rapid control of hypertensive emergencies resulted in a reduction in severe maternal morbidity.<sup>14</sup> A 2015 California study reported that 60% of maternal deaths due to preeclampsia were preventable, with stroke as a common cause of preeclampsia related death.<sup>15,16</sup> Although we did not see a change in maternal morbidity, the reduction in blood pressure seen here may ultimately translate to decreasing morbidity among women with hypertensive disorders of pregnancy. Stricter management of blood pressure may additionally have an effect on reducing readmissions. Previous data suggest that stricter blood pressure cutoffs may reduce postpartum hypertensive readmissions.<sup>17</sup> Although we found an increase in readmissions with our protocol, we found a decrease in blood pressure and prevalence of severe blood pressure.

Standardization of care has been shown to decrease racial disparities, with a prior study on induction of labor protocol noting reduction in cesarean delivery among Black women after implementation of a protocol.<sup>18</sup> The majority of our study cohort were women who were publicly insured and of Black race, both characteristics that are associated with disparities in postpartum care.<sup>19</sup> In particular, Black women are at a four to six times higher risk of death during pregnancy and postpartum.<sup>20</sup> We found that in this high-risk vulnerable patient population, our intervention improved adherence to postpartum visits and blood pressure with an equal effect size by race. The protocol, however, did not eliminate racial disparities in follow-up adherence. These racial disparities are likely secondary to systemic racism as opposed to biological differences in race, and further work is needed in identifying solutions and protocols to eliminate racial disparities.

Strengths of this study include the provision of specific protocols and interventions that were universal and followed consistently in all patients regardless of underlying diagnosis within hypertensive disorders of pregnancy, insurance type, race or type of obstetric provider. Our pragmatic study suggests that hospital-wide implementation of a care bundle in a large tertiary hospital with multiple learners (residents and fellows) can improve adherence to postpartum follow-up visits and blood pressure control.

Our study has limitations. Because we only studied patients at a single center, our findings may not be

generalizable to other hospitals or patient populations. Our bundle also included multiple interventions, and our data do not allow us to determine the relative contribution of each component. However, we believe that individual components of the intervention may be practically implemented regardless of the primary physician, which is important in many hospitals in which different practices deliver at one institution. The bundle includes low-cost interventions such as health care professional education and standardization of protocols, as well as interventions requiring resources such as a dedicated nurse educator, provision of blood pressure cuffs, and expansion of our clinical templates. The retrospective design of our study raises the possibility of residual confounding, including temporal changes in clinical practice or society guidelines. Most notably a change in definition of Stage 1 hypertension as a blood pressure of 130/80 occurred in 2019.<sup>21</sup> Importantly, obstetric guidelines for the definition of chronic hypertension did not change during this time period.<sup>22</sup> Larger studies are needed to examine the ability of a quality initiative bundle in the postpartum period to reduce rare outcomes such as severe maternal morbidity and mortality. Studies are also needed to assess patient satisfaction with implementation of these quality-improvement bundles. Notably, although all postpartum hypertension appointments were scheduled within our hospital system, we did not have data on patients whose appointments were at an alternate institution and may have underestimated the proportion with follow-up.

Taken together, our data provide support for bundled management of postpartum hypertension management both in the immediate inpatient and outpatient setting. We hope that demonstration of improved outcomes will support greater resource allocation to management of postpartum hypertension at all delivering institutions to reduce the increasing burden of hypertensive disorders of pregnancy in the United States. Further work is needed in determining how to reduce the persistent racial disparities, even after implementation that includes the addition of telehealth and remote blood pressure monitoring in addition to educational bundles.

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## PEER REVIEW HISTORY

Received May 23, 2021. Received in revised form July 23, 2021. Accepted July 29, 2021. Peer reviews and author correspondence are available at <http://links.lww.com/AOG/C456>.

