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AHA SCIENTIFIC STATEMENT

Opportunities in the Postpartum Period to Reduce Cardiovascular Disease Risk After Adverse Pregnancy Outcomes: A Scientific Statement From the American Heart Association

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ABSTRACT: Adverse pregnancy outcomes are common among pregnant individuals and are associated with long-term risk of cardiovascular disease. Individuals with adverse pregnancy outcomes also have an increased incidence of cardiovascular disease risk factors after delivery. Despite this, evidence-based approaches to managing these patients after pregnancy to reduce cardiovascular disease risk are lacking. In this scientific statement, we review the current evidence on interpregnancy and postpartum preventive strategies, blood pressure management, and lifestyle interventions for optimizing cardiovascular disease using the American Heart Association Life's Essential 8 framework. Clinical, health system, and community-level interventions can be used to engage postpartum individuals and to reach populations who experience the highest burden of adverse pregnancy outcomes and cardiovascular disease. Future trials are needed to improve screening of subclinical cardiovascular disease in individuals with a history of adverse pregnancy outcomes, before the onset of symptomatic disease. Interventions in the fourth trimester, defined as the 12 weeks after delivery, have great potential to improve cardiovascular health across the life course.

Key Words: AHA Scientific Statements ■ cardiovascular diseases ■ diabetes, gestational ■ postpartum period ■ pregnancy ■ pregnancy complications ■ primary prevention

Adverse pregnancy outcomes (APOs) can arise from stress of metabolic and vascular changes during pregnancy.[1–3] APOs include myriad maternal or fetal complications, including hypertensive disorders of pregnancy (HDP; gestational hypertension, preeclampsia, eclampsia, and HELLP [hemolysis, elevated liver enzymes, low platelets] syndrome), gestational diabetes, placental abruption, spontaneous preterm birth, fetal growth restriction, and small-for-gestational-age infant.[1] The prevalence of APOs is estimated to be 10% to 20% in the literature and varies by race and ethnicity.[2]

These APOs portend higher risk of future long-term complications, including increased lifetime risk of atherosclerotic cardiovascular disease (ASCVD), heart failure, stroke, chronic kidney disease (CKD), and vascular dementia.[1,3] This risk appears to be largely mediated by the increased incidence of cardiovascular disease (CVD) risk factors, including diabetes and hypertension.[4,5] Individuals with gestational diabetes, for instance, are 8 times more likely to develop subsequent type 2 diabetes compared with those without gestational diabetes.[6] Women with HDP have a 2- to 4-fold higher risk of developing chronic hypertension compared with women with normotensive pregnancies at 10 to 20 years or later after delivery.[7,8] These CVD risk factors, in turn, place postpartum individuals at a higher risk of developing subsequent CVD and other end-organ effects and thus are important targets for postpartum interventions.

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Furthermore, disparities by race and ethnicity, socioeconomic status, and geography (rural versus urban-dwelling individuals) affect the prevalence of APOs and subsequent cardiovascular sequelae. Compared with non-Hispanic White women, non-Hispanic Black women have an increased risk of developing HDP and severe maternal morbidity in the peripartum period and higher CVD risk across their life span.[9,10] CVD is a leading cause of pregnancy-related deaths and causes the most deaths in Black birthing individuals.[10,11] Given that race and ethnicity are social constructs, social determinants of health, economic status, and structural racism are key contributors to racial disparities in prenatal CVD risk factors, maternal access to care, and maternal and fetal outcomes.[11,12] An in-depth review of social determinants of health, their role in the development of CVD risk factors, morbidity and mortality in women and men, and the need for policy-level changes to mitigate disparities has been published previously.[13]

Despite these well-established associations, evidence-based guidelines are lacking to provide clinicians recommendations on how to reduce CVD risk and optimize cardiovascular health (CVH) after APOs. Given the robust data from epidemiological and clinical studies linking APOs and CVD, APOs have been highlighted as a CVD risk factor in multisociety scientific statements from the American Heart Association (AHA) and American College of Obstetricians and Gynecologists (ACOG).[14] No randomized clinical trials have evaluated the effects of postpartum interventions on long-term maternal CVD outcomes. Yet, the need for interventional strategies supported by rigorous evidence remains. In particular, the fourth trimester, defined as the 12 weeks after delivery, is an optimal time to engage postpartum individuals in care to reduce maternal morbidity and improve care transitions. The concept of the fourth trimester can be further extended to the first year after delivery as a critical time to assess long-term CVD risk and to implement lifestyle changes in order to improve maternal CVH across the life course with potential downstream impact on the CVH health of offspring.

This scientific statement is organized into 3 parts. First, current evidence on interpregnancy CVH, postpartum blood pressure (BP) trends, and lifestyle interventions is reviewed. Next, a pragmatic approach to postpartum management and preventive strategies for optimizing CVH using the AHA Life's Essential 8 framework[15] is presented (Figure 1). Last, this scientific statement highlights the need for postpartum CVD risk factor screening after an APO and future directions to define the role for screening for subclinical CVD in individuals with a history of APOs. In this scientific statement, we use gender-neutral language to refer to all individuals capable of pregnancy. We refer to women and men on the basis of presumed gender identity when used in published studies and guidelines.

POSTPARTUM AND INTERPREGNANCY HEALTH

Specific components of postpartum care have long-term implications for maternal CVH, especially for those who have experienced APOs. The interpregnancy period is an ideal opportunity to further reduce risk of future pregnancy complications for individuals who plan on future pregnancy. Postpartum and interpregnancy counseling for specific APOs is summarized in Table 1.

Breastfeeding has a multitude of benefits for maternal and offspring CVH. Longer duration of breastfeeding is associated with lower risk of type 2 diabetes, especially for those with a history of gestational diabetes, hypertension, and myocardial infarction.[16] Breastfed infants self-regulate intake and volume, develop early programming for self-regulation, and have improved CVH profiles in adulthood.[17] Breastfeeding rates may be suboptimal for populations that experience structural barriers to breastfeeding such as inadequate parental leave and lactation support, which require policy-level interventions.[18]

Most contraceptive options are safe in postpartum individuals with a history of APOs.[9,19] Combined estrogen-progestin hormonal contraception increases BP and generally is avoided in patients with stage 2 hypertension (even if treated), those with migraine with aura, and those with multiple CVD risk factors.[9] Combined hormonal contraception is likely safe in normotensive individuals with a history of HDP. Postpartum individuals are advised to avoid short-interval pregnancies (<6 months between birth and conception), especially with a history of preterm birth.[16]

The year after delivery is a critical time to optimize CVH in order to lower future risk of APOs, especially preeclampsia, for those who may have a subsequent pregnancy. Prior preeclampsia significantly increases the risk of preeclampsia in a subsequent delivery, with the greatest risk of recurrence associated with onset before 37 weeks' gestation.[20] Up to one-third of individuals with gestational diabetes will be diagnosed with diabetes or impaired glucose metabolism within 12 weeks after delivery.[21,22] Prior gestational diabetes is also associated with recurrent gestational diabetes in future pregnancy. Prepregnancy hypertension and diabetes are associated with preeclampsia, preterm birth, and intrauterine fetal demise.[21] Optimal control of hypertension and diabetes before and during pregnancy is associated with lower risk of adverse maternal and neonatal outcomes, emphasizing the importance of CVD risk factor diagnosis and treatment during the interpregnancy period.[23–25] During subsequent pregnancy, low-dose aspirin (81 mg/d) reduces the risk and severity of preeclampsia for individuals with chronic hypertension, type 2 diabetes, history of preeclampsia, or other risk factors.[26]

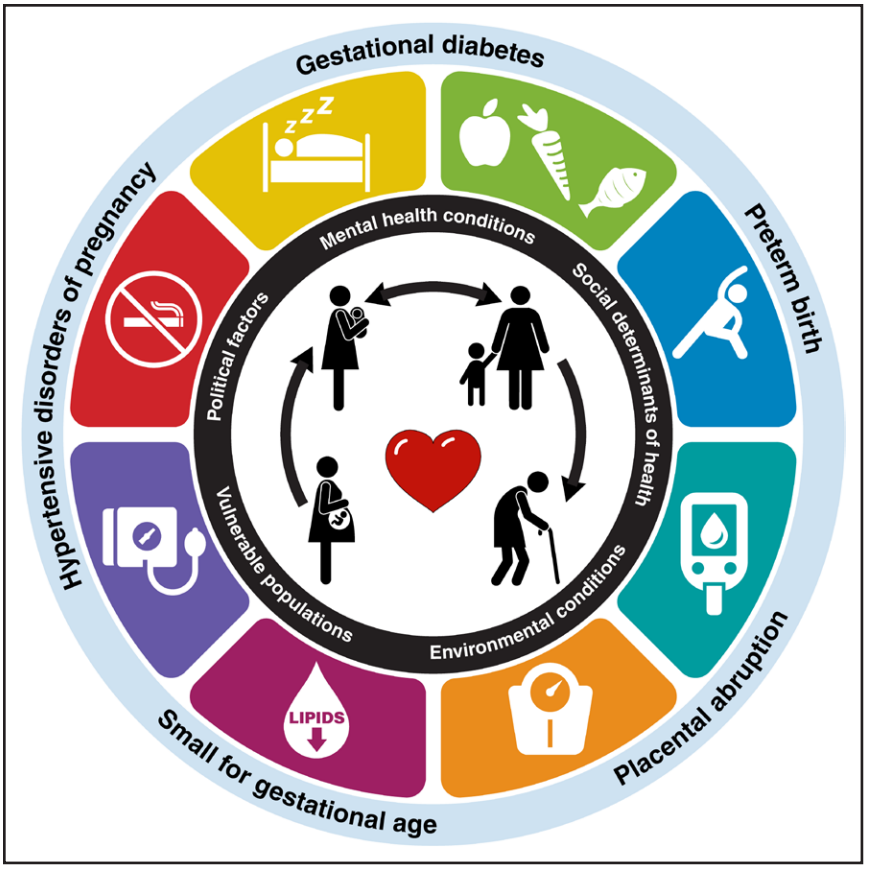

Figure 1. Opportunities to improve CVH in the postpartum period after adverse pregnancy outcomes.[15] Improvements in postpartum maternal cardiovascular health (CVH) may help reduce risk of future adverse pregnancy outcomes (bidirectional arrow), which may additionally attenuate maternal and offspring cardiovascular risk. Modified with permission from Lloyd-Jones et al.[15] © 2022 American Heart Association, Inc.

POSTPARTUM BP MANAGEMENT

Postpartum hypertension often results from preeclampsia or a gestational hypertension diagnosis during pregnancy or chronic hypertension. A small proportion of patients with previously normotensive pregnancies will develop preeclampsia de novo in the postpartum period.[27] Risk factors for de novo postpartum preeclampsia are similar to those for preeclampsia before delivery. Patients most commonly present with headache or other neurological symptoms.[28] Postpartum hypertension and preeclampsia contribute to serious short-term maternal complications such as stroke, seizures, and cardiomyopathy[27,29] and early warning signs and symptoms are often missed.[30] Careful management of postpartum BP may reduce maternal morbidity and mortality.[31,32]

BP Trajectory

BP in individuals with HDP diagnosed during pregnancy typically peaks between postpartum days 3 and 6 as a result of the delayed mobilization of extravascular fluid into the intravascular space and physiological decline of vasodilatory hormones.[33] BP then rapidly decreases over the first 3 weeks after delivery, with slower declines thereafter. Several factors during the immediate postpartum period may exacerbate the risk of hypertension, including the generous use of intravenous fluids and the preferential use of nonsteroidal anti-inflammatory drugs (NSAIDs) for postpartum analgesia. Although postpartum NSAID use was not found to be associated with higher BP in a meta-analysis, studies were limited by small sample sizes and durations of follow-up.[34] NSAID therapy in the setting of renal disease and chronic hypertension may cause worsening hypertension, similar to nonpregnant individuals. We suggest additional investigations to address the impact of longer duration of postpartum NSAID use for those at risk and careful consideration of analgesic options until then.

As for alternative analgesics, a recent study showed that 4 g acetaminophen taken daily over a 2-week period increases systolic BP in older hypertensive individuals.[35] The results of this study should be interpreted with caution in the context of the lower acetaminophen dosing commonly used for postpartum analgesia. Given limited analgesic options in the postpartum period, future studies should address the safety of acetaminophen use in the postpartum period.

Diuretics should also be considered for postpartum hypertension, which may be exacerbated by an increase in intravascular fluid volume after delivery. A recent randomized controlled clinical trial showed that a 5-day course of furosemide in postpartum women with HDP was associated with a 60% reduction in hypertension at day 7 after delivery.[36]

Table 1. Postpartum and Interpregnancy Counseling for Patients With Specific APOs

	Counseling	Management	Lactation considerations	Subsequent pregnancy	Contraception
HDP	BP returns to baseline levels by 12 wk postpartum, but hypertension can persist in some patients 2- to 4-fold increased risk of developing chronic hypertension 2-fold increased risk of developing subsequent CVD; risk is higher in patients with preeclampsia with early onset, severe features, or recurrence	Wean BP medication as appropriate Ideal BP <120/80 mm Hg with BP goal <130/80 mm Hg for patients with treated chronic hypertension Lifestyle changes for patients with stage I or stage II hypertension Glucose and lipid screening if not up to date Serum creatinine and proteinuria assessment if history of elevated creatinine, AKI, proteinuria, or prepregnancy kidney disease*	Breastfeeding may reduce future risk of chronic hypertension Avoid angiotensin receptor blockers and ACE inhibitors, except for enalapril and captopril, which are considered safe while breastfeeding Diuretics may affect milk supply if used in high doses	Patients with preeclampsia have risk of recurrence in future pregnancy. Discuss aspirin in future pregnancy to reduce recurrence risk. Good BP control before and during pregnancy can reduce preeclampsia risk	Avoid estrogen-containing contraception (eg, combined oral contraceptive pills or patch) if hypertensive or treated hypertension
Gestational diabetes	8-fold increased risk of developing T2D Increased risk of subsequent CVD	2-h oral GTT at 4–12 wk postpartum Lipid screening if not up to date Weight loss and exercise for diabetes prevention; consider metformin if prediabetic; refer to DPP	Breastfeeding may reduce future risk of T2D	Risk of recurrent gestational diabetes in future pregnancy High prepregnancy weight associated with increased recurrence risk	
Other APOs: placental abruption, SGA infant, preterm birth	Increased risk of subsequent CVD	Lipid and glucose screening if not up to date			

ACE indicates angiotensin-converting enzyme; AKI, acute kidney injury; APO, adverse pregnancy outcome; BP, blood pressure; CVD, cardiovascular disease; DPP, Diabetes Prevention Program; GTT, glucose tolerance test; HDP, hypertensive disorder of pregnancy; SGA, small-for-gestational-age; and T2D, type 2 diabetes.

*Creatinine is usually checked within 1 week after delivery. Proteinuria (as assessed by 24-hour urine collection, albumin-to-creatinine ratio, or protein-to-creatinine ratio) can persist for months after delivery, and repeat assessment at 6 to 12 months may be reasonable.

Patient education and postpartum follow-up are critical to the prevention and early treatment of severe hypertension and its complications. Home BP monitoring, including text-based communication, and telemedicine programs have improved BP monitoring rates, have increased postpartum obstetric visits, and are associated with fewer emergency department visits and hospital readmissions for hypertension.[31,37–39] It is important to note that remote BP monitoring has been found to be feasible in racially diverse populations and reduces disparities in postpartum BP monitoring.[40] Home BP monitoring programs increasingly are becoming the standard of care and may offer opportunities to better understand BP trajectories and the risk of developing chronic hypertension. Future studies should investigate how home BP monitoring may reduce inequities in access to care in other populations, including rural-dwelling individuals.

In single-center cohort studies, an estimated 18% to 57% of women will continue to need antihypertensive medication or have BP values meeting criteria for stage 2 hypertension when evaluated between 6 weeks and 4 months postpartum.[29,41–43] Ambulatory BP monitoring may additionally detect hypertension missed during office visits.[29,44] Factors associated with persistent hypertension include older maternal age, obesity, higher BP in early pregnancy, preeclampsia with severe features, and discharge from the delivery admission on BP medications.[41–43] Nationwide cohort studies in Denmark and France suggest lower rates of chronic hypertension at 1 year after delivery, although a diagnosis of HDP was still associated with up to a 12-fold to 25-fold higher risk of hypertension within the first year of delivery compared with women with normotensive pregnancies.[7,45] Differences in the estimate of chronic hypertension in the year after delivery may be related to patient or geographic factors, study design, or the definition of chronic hypertension outcome (eg, measured BP during office or study visit versus prescription fill for BP medication). The diagnosis of secondary hypertension requiring further evaluation should be considered in the presence of classic clues, signs, and symptoms, including maternal age <35 years; severe or resistant hypertension; the presence of laboratory abnormalities such as hypokalemia, albuminuria, or elevated creatinine; and obesity-related obstructive sleep apnea. Renin and aldosterone levels decrease within the 6 weeks after delivery, after which time case detection of hyperaldosteronism may improve.

Individuals with CKD have an elevated risk of developing preeclampsia because of comorbid conditions such as hypertension and vascular and metabolic abnormalities. In turn, preeclampsia can cause acute kidney injury or proteinuria, or both, regardless of prepregnancy kidney disease, and increase future risk of CKD.[46,47] Both acute kidney injury and CKD further contribute to elevated

CVD risk. Repeat assessment of postpartum renal function and proteinuria may help identify those at risk for both CVD and CKD and facilitate early diagnosis and treatment. The optimal timing of proteinuria testing is not established and may vary with clinical context.

Hypertension After an APO: Longer-Term Implications

Individuals who experience HDP have increased risk of developing chronic hypertension in the early postpartum years. A study of 4484 nulliparous women followed up prospectively since early in pregnancy found that those who experienced HDP had more than double the risk of developing new chronic hypertension within 2 to 7 years after delivery (adjusted relative risk, 2.7 [95% CI, 2.0–3.6]).[48] Women who had medically indicated preterm birth (before 37 weeks' gestation) and HDP had the highest risk of developing subsequent new hypertension (relative risk, 4.3 [95% CI, 2.7–6.7]).[48] Hypertension, particularly in women, confers an increased risk of cardiovascular and cerebrovascular disease; the INTERSTROKE study found that the population attributable risk of hypertension for stroke was 52.3% in women compared with 45.2% in men,[49] and the INTERHEART study similarly found that hypertension was a stronger risk factor for myocardial infarction in women compared with men.[50] Of note, women experience increased stroke risk at lower BP compared with men.[51] Women with a history of 1 or more APOs experience myocardial infarction and stroke at younger ages compared with those without APOs.[52,53] Early detection and treatment of hypertension after pregnancy thus may yield downstream benefits for prevention of myocardial infarction, heart failure, and stroke, especially among those who have experienced 1 or more APOs. A history of HDP and other APOs furthermore should be considered a strong risk factor in the evaluation of a young adult with cardiac or stroke-like symptoms; these symptoms are more likely to be misdiagnosed as mimics (eg, anxiety attack, complicated migraine) in young women.[54–57]

Capturing Hypertension Outside the Primary Care Setting

Significant barriers exist in accessing regular primary care postpartum in birthing individuals. Therefore, postpregnancy hypertension may go undiagnosed and untreated until the next pregnancy or years later when end-organ manifestations develop prematurely.[52] Every medical encounter, however, presents an opportunity for early hypertension detection (Figure 2). Urgent care or emergency department visits for injuries, minor illnesses, or headache may identify elevations in BP in young adults, which should not be attributed to exclusively anxiety or pain because elevated BP in these settings is associated with long-term ASCVD.[58] These patients should receive prompt counseling and referral to primary care to ensure that a follow-up BP check is scheduled. Many other specialists besides those in primary care may interact with pregnancy-capable adults of reproductive age. Neurologists often see patients with headache disorders, which affect more than half of women 20 to 64 years of age[59]; these encounters also offer an opportunity to screen for and detect elevated BP, which in turn may reflect untreated sleep apnea in a patient with frequent headaches.[60] Dermatologists frequently treat acne or other skin conditions in individuals capable of pregnancy, which may be a consequence of underlying conditions (eg, polycystic ovarian syndrome) associated with hypertension.[61] Educational outreach to emergency department and specialist health care professionals on CVD complications of pregnancy is necessary to improve patient screening, referral, and treatment.

EVIDENCE FOR POSTPARTUM LIFESTYLE MODIFICATION INTERVENTIONS

Lifestyle interventions that target achieving a healthy weight, healthy diet, and regular physical activity reflect Life's Essential 8, the AHA's approach to optimal CVH across the life course.[15] A cross-sectional study of 26 543 women of childbearing age reported that only 4.8% had ideal CVH across 7 metrics, with non-Hispanic Black women least likely to have ideal CVH, especially for BP, blood glucose, and body mass index.[62]

Postpartum Weight Management Interventions

Obesity increases risk for APOs, including HDP, gestational diabetes, and pregnancy loss. Obesity also increases risk for future CVD after APOs. Risk for obesity itself is increased by postpartum weight retention; indeed, 60% of individuals retain weight a year after delivery, with many gaining additional weight.[63] The postpartum period is thus a critical window for healthy weight management and cardiovascular risk reduction through lifestyle modifications.

In post hoc analyses, the landmark Diabetes Prevention Program (DPP) demonstrated that an intensive lifestyle intervention targeting weight loss and physical activity successfully reduced diabetes incidence by 50% compared with placebo among individuals with a history of gestational diabetes.[64] Of note, participants with prior gestational diabetes were not the primary focus in this trial and were enrolled 12 years postpartum on average.[64] The primary goals of the intensive lifestyle intervention were to reach and maintain a weight loss of at least 7% of initial body weight, achieved through behavioral strategies such as goal setting, self-monitoring, and dietary changes in fat and calorie intake, and engaging in at least 150 minutes of moderate-intensity physical

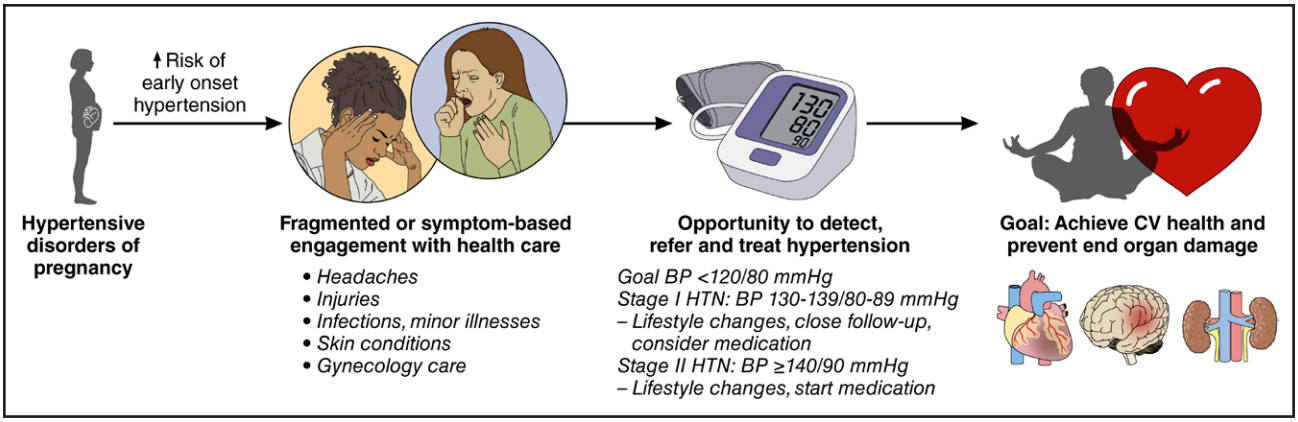

Figure 2. Opportunities to identify and treat chronic hypertension in postpartum individuals.
BP indicates blood pressure; CV, cardiovascular; and HTN, hypertension.

activity per week. This approach has been disseminated at scale through the National Diabetes Prevention Program, a public-private partnership to deliver a 12-month lifestyle intervention aiming for 5% weight loss and 150 min/wk of physical activity for individuals at high risk for type 2 diabetes (including those with a history of gestational diabetes).[65] Subsequent trials have built on the success of the DPP lifestyle intervention specifically to reduce postpartum cardiometabolic risk.

Among randomized clinical trials evaluating lifestyle interventions focused on postpartum weight within the past 5 years, 6 randomized clinical trials tested interventions delivered exclusively in the postpartum period (Supplemental Table).[66–71] Of these, 3 trials included individuals with gestational diabetes,[66,69,70] and 2 trials focused primarily or exclusively on Hispanic participants.[67,70] Four of the 5 trials reported significant intervention effects on primary outcomes of body weight.[66–69] For trials with follow-up periods of ≥6 months, between-group differences in weight change ranged from 4.5 kg at 6 months[69] to 2.3 to 3.3 kg at 12 months.[66,67] Intervention components in these successful trials included lifestyle coaching; goal setting for calorie intake and physical activity; self-monitoring and feedback of weight, diet, and physical activity health behaviors; text messages; and multimedia educational material. Many leveraged digital technologies. Only 1 trial reporting significant intervention effects on postpartum weight focused on participants of underrepresented races and ethnicities or low-income; this was also the largest trial, with >370 participants in the Special Supplemental Nutrition Program for Women, Infants, and Children.[67] This trial demonstrated that an internet-based intervention, derived in part from the DPP and integrated into the Special Supplemental Nutrition Program for Women, Infants, and Children care delivery setting, effectively promoted postpartum weight management.

An additional 5 randomized clinical trials tested interventions extending from pregnancy to postpartum.[72–76] Three of the 5 trials reported significant intervention effects on primary outcomes of body weight. One of the largest trials tested the comparative effectiveness of a health system–based, DPP-derived intervention on 12-month postpartum weight loss in 2280 individuals with gestational diabetes receiving care through Kaiser Permanente Northern California.[72] The primarily telehealth intervention resulted in 28% greater odds of meeting weight goals compared with usual care in this pragmatic trial. Parents as Teachers (PAT) is a national evidence-based home visiting program designed to improve parenting knowledge and skills. The PAT program plus lifestyle intervention during pregnancy and 12 months postpartum was compared with the PAT standard protocol among low-income Black individuals. The combined intervention, which incorporated an adaptation of the DPP within the standard PAT curriculum and home visits, resulted in significantly greater likelihood of returning to baseline weight at 12 months postpartum among trial completers (n=185/267).[74] In a different patient cohort, the combination of the PAT program plus lifestyle intervention resulted in no differences in weight compared with the PAT program alone at 12 months postpartum and may be related to study design, lifestyle curriculum, and smaller sample size.[73,77,78]

These studies found no between-group differences in self-reported physical activity. A study that measured step count with a pedometer found improvement from baseline to 12 weeks in the intervention group compared with the control group, but this was not maintained at 1 year.[71] Last, a study measuring physical activity with a wrist-worn accelerometer found no between-group differences in physical activity at 6 or 12 months.[67] Of concern is that in most of these studies, participants demonstrated a low volume of exercise at follow-up. Considering that the AHA's Life's Essential 8 recommends at least 150 minutes of moderate to vigorous physical activity each week, future studies might strengthen the physical activity component of their interventions to yield the many physical and psychosocial benefits, which was the focus of another recent AHA scientific statement.[79]

Limitations in prior trials include small sample sizes, self-reported rather than objectively measured weights and physical activity, and high attrition, with the lowest retention in trials attempting to retain Black women from rural geographic regions. Furthermore, because most intervention components were delivered as a package, it is unclear which components were most successful. A multiphase optimization strategy framework could determine the active ingredient of these lifestyle interventions.[80]

Weight loss interventions may also include pharmacological options such as glucagon-like peptide 1 receptor agonists or bariatric surgery for eligible patients.

Postpartum Interventions Targeted to Populations With HDP

Few studies have focused on improving CVH after pregnancy complicated by HDP.[81–83] Among postpartum individuals with recent HDP, a gamified digital health intervention (involving text messages providing feedback, social incentives, and points for meeting goals) with wearable activity trackers was effective in increasing daily step counts over a 12-week period.[82] A key strength of this study was the diverse recruitment, with 55% of individuals self-reporting Black race. A more longitudinal intervention study, Heart Health 4 Moms, randomized participants with a history of preeclampsia within the previous 5 years to an online intervention program that included educational modules, a community forum, and a lifestyle coach. The intervention group reported a statistically significant increase in knowledge of CVD risk, increased healthy eating, and less physical inactivity.[83]

Although existing evidence supports the effectiveness of lifestyle interventions to reduce risk of postpartum weight retention, additional studies are needed to understand the impact of such interventions on other CVH metrics such as BP and glucose control. Opportunities for impact include delivering digital and telehealth interventions and reaching postpartum patients within health systems and community-based settings such as the Special Supplemental Nutrition Program for Women, Infants, and Children and home visitation programs (Figure 3).[67,74] Indeed, of National Diabetes Prevention Program participants with a remote history of gestational diabetes, 77.1% (29 037) joined an online program (ie, asynchronous delivery) rather than an in-person, distance-learning (synchronous), or combined-modality program.[84] Programs that are delivered online, programs delivered in participants' own homes or community settings, or a hybrid of both formats may offer the flexibility necessary to meet the needs of younger birthing individuals. Additional trials are needed that are focused on individuals with APOs, address clinical outcomes, and address methodological limitations such as small sample sizes, trial attrition, and self-reported rather than measured outcomes. With some exceptions, the trials discussed previously target individual-level behavior change. Upstream interventions spanning multiple levels—from communities and built environments to policy and systems change—offer opportunities to address the social determinants of health that contribute to maternal CVH disparities and to increase intervention reach, effectiveness, and sustainability.[85,86] Additional trials are needed that focus on groups burdened by structural racism, who contribute to disparities in APOs and subsequent CVD outcomes.

POSTPARTUM OPTIMIZATION OF CVH: A PRAGMATIC APPROACH FOR CLINICIANS

The postpartum and interpregnancy time frames are critical time windows in which implementation of a comprehensive multidisciplinary plan and careful consideration of CVD risk factors are important to reduce adverse maternal outcomes and for the implementation of innovative care delivery models for those affected by APOs.[15,87,88] We provide in this section a timeline and framework for risk factor screening and specific interventions to improve CVH based on the AHA's Life's Essential 8 construct (Figure 4).[15]

A recent AHA scientific statement recommended frequent cardiac risk factor screening assessments in the first year postpartum at 6 weeks, 12 weeks, 6 months, and 12 months, with appropriate transition from postpartum to longitudinal primary care around the 8- to 12-week mark.[1] Screening and promoting CVH across the life course could be implemented with the Life's Essential 8 framework as outlined in a recent AHA presidential advisory.[15] Current literature promotes a framework that intervenes early and provides sustainable solutions within 1 year postpartum. Many interventions can be achieved by use of telemedicine, digital health, and self-monitoring at the individual, health system, and community levels (Figure 3). Reinforcement of lifestyle counseling and ongoing sex-specific risk assessment over time will be needed to potentially modify the long-term risk trajectory of CVD.

Identification of barriers and implementation of solutions that incorporate different team members to improve retention of individuals are essential given that up to 40% of women do not participate in postpartum care and only an estimated 18% to 25% of postpartum patients with APOs or chronic health conditions are seen by a primary care clinician within 6 months of delivery.[88–90] Obstetrician-gynecologists are the primary care clinician for many individuals capable of pregnancy. The ACOG and AHA have released a joint presidential advisory calling for enhanced collaboration and coordination of care between obstetrician-gynecologists and cardiologists, particularly for CVD risk factor screening and integrated

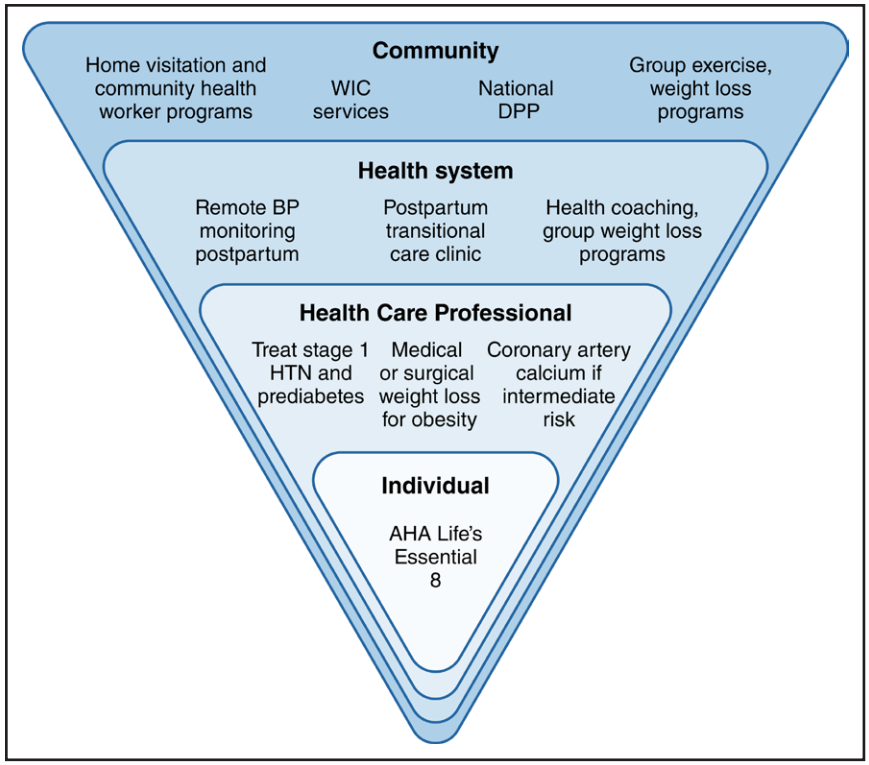

Figure 3. Interventions to reduce CVD risk according to an ecological framework.
National policies to reduce maternal cardiovascular disease (CVD) risk include Medicaid expansion to ensure access to preventive care and contraception. AHA indicates American Heart Association; BP, blood pressure; DPP, Diabetes Prevention Program; HTN, hypertension; and WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

models of care.[14] Table 2 lists strategies to improve postpartum care engagement.

BP Monitoring and Pharmacotherapy

Early BP treatment for postpartum severe hypertension is critical to prevent adverse maternal events. The choice of medications should no longer be limited by concerns of fetal exposure in utero and can be extended to those that are safe during breastfeeding. Labetalol, nifedipine, and amlodipine are commonly used postpartum.[91] Calcium channel blockers offer the convenience of once-daily dosing but may cause headaches, which can affect medication adherence. Enalapril can be used safely

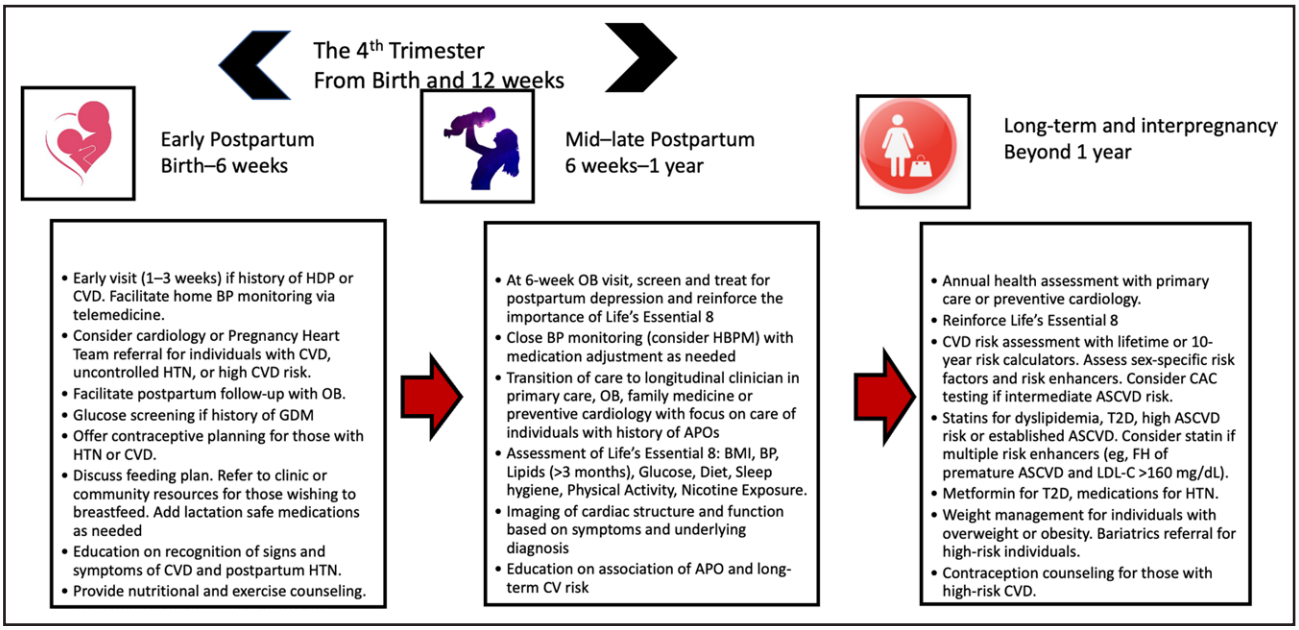

Figure 4. Strategies and timeline to reduce cardiovascular risk after APOs.
APO indicates adverse pregnancy outcome; ASCVD, atherosclerotic cardiovascular disease; BMI, body mass index; BP, blood pressure; CAC, coronary artery calcium; CV, cardiovascular; CVD, cardiovascular disease; FH, family history; GDM, gestational diabetes; HBPM, home blood pressure monitoring; HDP, hypertensive disorders of pregnancy; HTN, hypertension; LDL-C, low-density lipoprotein cholesterol; OB, obstetrician; and T2D, type 2 diabetes.

Table 2. Strategies to Improve Engagement With Postpartum Visits With Multidisciplinary Care Coordination

Types	Specific Challenges	Solutions
Patient level	Competing priorities Lack of self-prioritization Dependent care	Booking the postpartum follow-up prenatally Enlisting family and friends to assist with practical needs such as infant care, household chores, transportation Patient counseling Postpartum doula services
Practice level	Staffing shortages Clinician bias Maternity care deserts	Telemedicine, digital tools, texts, phone calls to encourage participation Screening for social determinants of health and community referrals
Ecological level	Adverse social determinants such as health literacy, lack of language support, transportation, unsafe neighborhoods, access to clinics, underresourced and rural-dwelling communities	Patient navigators speaking native languages Home visiting nurses to check postpartum BP Community health workers embedded in the neighborhood to deliver health education and safe postpartum practices Medicaid expansion to 1 y postpartum Parental leave policies Enhanced services to meet social determinants of health such as housing and transportation

BP indicates blood pressure.

during lactation.[92] Timely volume management in the postpartum period coupled with the judicious use of NSAIDs for pain control may reduce maternal hypertension morbidity and circumvent the need for hypertension-related hospitalizations. Home BP monitoring programs should be used, when available, to improve BP monitoring and treatment in the weeks after delivery.

Current BP guidelines from the American College of Cardiology/AHA[93] and ACOG[22] do not specify BP goals in the postpartum period. The threshold for BP treatment postpartum, as a result, is extrapolated from ACOG guidelines to treat BP ≥160/110 mm Hg in pregnant patients with preeclampsia.[30] Treatment thresholds for chronic hypertension in pregnancy recently have changed on the basis of the CHAP trial (Chronic Hypertension and Pregnancy) to <140/90 mm Hg. However, CHAP was a trial of individuals with chronic hypertension, and current BP targets remain higher for management of preeclampsia or postpartum hypertension because lower BP goals in these subsets of the populations have not been well studied.[94] In contrast, UK-based National Institute for Health and Care Excellence guidelines for hypertension in pregnancy[92] support postpartum BP goals that are consistent with hypertension goals in nonpregnant adults.[95] Although US-based studies are needed to confirm the optimal BP threshold in postpartum individuals, it may be reasonable to consider postpartum BP goals based on those established for nonpregnant, age-matched individuals. For patients initiated on BP treatment during pregnancy or the postpartum period, medications should be continued until normal BP readings are achieved. Self-management of BP medication using established algorithms in the context of close clinical follow-up has been shown to be feasible in select populations.[96]

Individuals with persistent hypertension after delivery should be treated according to current American College of Cardiology/AHA BP guidelines.[93] Stage 1 hypertension is especially common after HDP, and affected individuals should receive intensive lifestyle counseling and close follow-up to assess CVD risk and need for medication initiation. Future studies are needed to determine the effectiveness of pharmacological treatment of stage 1 hypertension to prevent progression to subclinical CVD among individuals with prior HDP.[97]

Blood Glucose Monitoring

Women with gestational diabetes should be screened for dysglycemia at 4 to 12 weeks postpartum with a 2-hour 75-g oral glucose tolerance test, as recommended by the American Diabetes Association.[25] Given the low rates of oral glucose tolerance test uptake,[98,99] glucose screening with hemoglobin A1c or fasting glucose should be considered within the first year postpartum for those who do not complete an oral glucose tolerance test. Early postpartum oral glucose tolerance test testing (ie, before hospital discharge) is another promising strategy to improve diabetes screening. Lifelong screening for diabetes or prediabetes is recommended every 1 to 3 years for individuals with a history of gestational diabetes and may be considered for those with a history of any APO.

Blood Lipids

Given low rates of lipid screening among women of reproductive age,[100] checking a lipid panel within the first year postpartum to establish a baseline is reasonable to screen for familial hypercholesterolemia and for assessment of ASCVD risk. Lipid levels may take up to 3 months to return to prepregnancy levels and are minimally affected by lactation or use of oral contraceptive pills; these effects are unlikely to be clinically significant.[101] Early lipid

testing at the 6-week postpartum visit may be indicated in patients with suspected familial hypercholesterolemia or those who experience barriers to accessing primary care. Intensive lifestyle changes are recommended for all individuals with dyslipidemia. Statins can be used in individuals who are not lactating with established indications according to the 2018 cholesterol guidelines.[102]

Nicotine Exposure

Avoidance of nicotine exposure is recommended in all individuals to improve CVH. Thus, the ACOG recommends that all types of tobacco and nicotine use, including cigarette smoking or vaping products and hookahs, be avoided in the postpartum period and that clinicians offer psychosocial, behavioral, and pharmacotherapy interventions.[103]

Postpartum Weight Management and Health Behaviors

Current evidence supports the effectiveness of lifestyle interventions to reduce the risk of postpartum weight retention and to improve postpartum weight in those with overweight or obesity. Referral to lifestyle interventions such as the National Diabetes Prevention Program or programs incorporating DPP elements is recommended for individuals with a history of gestational diabetes and can be considered for individuals with other APOs. Behavioral health coaches, digital technology, and integrated community-based programs hold particular promise for postpartum individuals. Many of these multicomponent interventions also have the potential to improve diet and physical activity. The US Department of Health and Human Services recommends 150 minutes of moderate-intensity exercise per week in the postpartum period. Exercise routines may be resumed or started postpartum gradually and after discussion with the obstetrician-gynecologist. Brisk walking with a baby in a carrier or stroller can help postpartum individuals achieve exercise goals and improve CVH, especially if time and childcare help are limited.

Sleep

The peripartum period is a vulnerable time for maternal sleep disturbances. After delivery, individuals experience increased nocturnal awakenings, more fragmented sleep, and impaired sleep efficiency. Poor sleep quality is also associated with postpartum depression. Nonpharmacological interventions such as massage and exercise have been found to improve subjective reports of maternal sleep.[104] Pregnancy is also a risk factor for obstructive sleep apnea, which is associated with APOs and adverse neonatal outcomes.[105] Obstructive sleep apnea can take up to 6 months to resolve, and some patients may go on to develop persistent obstructive sleep apnea.[106] All patients with obstructive sleep apnea during pregnancy should undergo evaluation by a sleep medicine specialist after delivery.[105]

Additional Postpartum Factors Influencing CVH

Lactation

The ACOG recommends exclusive breast milk for an infant's first 6 months of life, with continued breastfeeding as foods are introduced during the first year of life and up to 2 years. The effects of lactation on reduction of cardiometabolic risk factors should be stressed.[107–109] Policy-level interventions to promote optimal support for lactating individuals, including paid maternity leave, access to lactation consultants, and affordable supplies for pumping, are needed simultaneously.

Postpartum Depression and Mood

Up to 10% of birthing individuals experience postpartum depression during the first year after delivery, and regular screening at obstetrician-gynecologists visits is recommended by several organizations.[110,111] Maternal screening at pediatric clinics and colocating maternal and pediatric care are proposed solutions to improving maternal health.[112] There are several validated screening scales for early recognition of postpartum depression, and early recognition in the postpartum period can lead to appropriate therapeutic interventions to improve maternal outcomes.

FUTURE DIRECTIONS TO ASSESS RISK OF SUBCLINICAL AND CLINICAL CVD

The 2019 American College of Cardiology/AHA primary prevention guidelines identified APOs as a risk-enhancing factor for ASCVD to guide clinician-patient discussions of lipid-lowering therapy among individuals 40 to 79 years of age after quantitative assessment of 10-year ASCVD risk with the Pooled Cohort Equations.[113] Most postpartum individuals, however, are <40 years of age and are likely to be at low absolute 10-year risk. For adults 20 to 59 years of age, the guidelines recommend that 30-year risk assessment can be helpful. However, implementation, communication, and evidence-based interventions based on 30-year CVD risk assessment remain poorly defined, with no specific guidance for those who have experienced an APO. Therefore, as highlighted in expert consensus documents and by national funding agencies, critical barriers to actualize strategies for CVD prevention in young adults remain, particularly among postpartum individuals who experience an APO.[114,115]

Detection of subclinical CVD (eg, atherosclerosis on computed tomography, silent cerebrovascular disease, or left ventricular remodeling on echocardiogram) before the development of overt symptomatic disease among risk-enhanced populations can inform

personalization of preventive interventions (eg, intensive BP lowering, lipid-lowering therapy).[116] Current guidelines recommend consideration of coronary artery calcium (CAC) in middle-aged to older adults who are at intermediate 10-year risk of ASCVD but do not specifically recommend the use of CAC among those with a history of APOs.[113] Available observational data suggest that women with a history of APOs have a higher prevalence of CAC in midlife, but it remains unclear whether APOs are a marker or mediator of future ASCVD. Among women in CREw-IMAGO (Cardiovascular Risk Profile: Imaging and Gender-Specific Disorders), any CAC was significantly more prevalent in women who self-reported a history of preeclampsia (20%) compared with those with normotensive pregnancies (13%).[117] However, presence of CAC was not significantly different by preeclampsia status in women <45 years of age, which suggests limited utility of this tool in younger women. This is not surprising because CAC represents a later stage of the disease course that is often not present in women until later in life. In the Swedish Cardiopulmonary Bioimage Study, which enrolled 10 528 women 50 to 65 years of age with at least 1 live birth, a history of APO was associated with a significantly higher prevalence of any atherosclerosis (including noncalcified plaque).[118] Therefore, identifying clinical populations in whom screening for atherosclerosis may better identify risk, personalizing clinical management, and improving hard outcomes are important targets of future clinical trials.

Individuals with a history of APO, in addition to increased risk for ASCVD, are at higher risk for heart failure, and distinguishing risks for CVD subtypes may inform differential strategies for screening, detection, and prevention. In a study at a single tertiary care center of 132 women with mean age of 38 years at the time of echocardiogram, having a history of HDP ≈10 years earlier compared with women with normotensive pregnancies was associated with a higher prevalence of left ventricular remodeling.[119] Although physiological remodeling of the left ventricle occurs during pregnancy, it remains unclear whether the presence of pathological left ventricular remodeling postpartum is the result of persistence of abnormal changes due to an APO or if it preceded pregnancy according to preexisting CVD risk factor profiles among those likely to develop an APO. In addition, limited data are available on laboratory-based biomarker levels (eg, BNP [B-type natriuretic peptide], high-sensitivity troponin) in the postpartum period.

Although great attention has been paid in recent years to the association between APOs and heightened short- and long-term risks of CVD, the pathways and mechanisms by which APOs are related to increased risk of CVD remain unclear, which limits the optimization of prevention strategies. Some potential future directions to prioritize include the following: (1) mechanistic studies to understand early vascular dysfunction after APO that may occur in the absence of CVD risk factors; (2) elucidation of the target population for, timing of, and methods for detection of subclinical CVD and cerebrovascular disease with laboratory and imaging-based biomarkers before the onset of clinically symptomatic disease (eg, ASCVD, heart failure, and stroke) in individuals who experience an APO; (3) incorporation of a life course approach in pregnancy and postpartum studies that integrates upstream or prepregnancy risk factors with a focus on prevention of APOs themselves; (4) multilevel strategies that prioritize primordial prevention (ie, prevention of risk factor development such as hypertension and diabetes); and (5) implementation studies to identify best strategies to modify long-term trajectory of CVD risk and to address significant and persistent gaps in evidence-based treatment once risk is identified. This is currently being investigated in ENRICH (Early Intervention to Promote Cardiovascular Health of Mothers and Children), an ongoing National Heart, Lung, and Blood Institute–funded multicenter trial testing the effectiveness of an implementation-ready intervention to promote CVH and to reduce CVH disparities.[120]

CONCLUSIONS

Interventions to mitigate APO-associated short-term and long-term CVD risks such as promotion of CVH based on the AHA Life's Essential 8 have great potential, particularly in the first 12 months postpartum, but require future study. Health system–based interventions that focus on transitions of care in the postpartum period, prioritize interrelated health and social needs of individuals at risk of readmission and disease progression, improve patient awareness, and offer postpartum screening for cardiovascular risk factors are the crux of postpartum care. Further studies on long-term reduction of CVD risk and implementation of policy-level changes that mitigate the adverse impact of social determinants of health with innovative health care delivery models and value-based care are essential, especially in resource-limited areas.

ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

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*Modest.

†Significant.

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