

Cumulative Lactation and Onset of Hypertension in African-American Women

Ellen M. Chetwynd, Alison M. Stuebe, Lynn Rosenberg, Melissa Troester, Diane Rowley, and Julie R. Palmer*

* Correspondence to Dr. Julie R. Palmer, Slone Epidemiology Center at Boston University, 1010 Commonwealth Avenue, 4th Floor, Boston, MA 02215 (e-mail: jpalmer@bu.edu).

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Hypertension affects nearly 1 of 3 women and contributes to cardiovascular disease, the leading cause of death in the United States. Breastfeeding leads to metabolic changes that could reduce risks of hypertension. Hypertension disproportionately affects black women, but rates of breastfeeding among black women lag behind those in the general population. In the Black Women's Health Study ($n = 59,001$), we conducted a nested case-control analysis using unconditional logistic regression to estimate the association between breastfeeding and incident hypertension at ages 40–65 years using data collected from 1995 to 2011. Controls were frequency-matched 2:1 to 12,513 hypertensive women by age and questionnaire cycle. Overall, there was little evidence of association between ever breastfeeding and incident hypertension (odds ratio = 0.97, 95% confidence interval: 0.92, 1.02). However, age modified the relationship ($P = 0.02$): Breastfeeding was associated with reduced risk of hypertension at ages 40–49 years (odds ratio = 0.92, 95% confidence interval: 0.85, 0.99) but not at older ages. In addition, risk of hypertension at ages 40–49 years decreased with increasing duration of breastfeeding (P for trend = 0.08). Our results suggest that long-duration breastfeeding may reduce the risk of incident hypertension in middle age. Addressing breastfeeding as a potential preventative health behavior is particularly compelling because it is required for only a discrete period of time.

African Americans; breastfeeding; case-control studies; hypertension; lactation; obesity; women's health

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

Hypertension affects nearly 1 in every 3 women (1) and is a contributor to cardiovascular disease, which is the leading cause of death in the United States (2, 3). Risk of cardiovascular disease later in life may be influenced by the metabolic changes that occur during pregnancy (4–6). These metabolic changes include increased central adiposity (7), an elevation in blood pressure (8), an atherogenic lipid profile (9), and insulin resistance (9). After pregnancy, lactation may be an important component of a woman's return to her prepregnancy metabolic state. Compared with formula-feeding women, lactating women utilize accumulated adipose tissue for milk production and have less inflammation, greater insulin sensitivity (10), beneficial changes in cardiac output (11), less atherogenic blood lipid profiles (12), and increased caloric utilization (10). These favorable changes during lactation have been termed the “reset hypothesis” and have been posited as a possible mechanism underlying differential risks of metabolic diseases later in life for women who have breastfed compared with women who have formula-fed (13).

The association between lactation and metabolic conditions has important implications for health disparities, because black women in the United States are both more likely to develop metabolic disease and less likely to breastfeed. Black women in the United States have a disproportionately high prevalence of hypertension (42.1%) compared with other populations (white women, 28.0%; Hispanic women, 26.0%) (1). Higher morbidity from hypertension and cardiac disease earlier in the life cycle among black women results in nearly twice the productive life lost compared with white women (14). Additionally, black women have lower breastfeeding initiation (66.4%) compared with white (83.0%) and Hispanic (82.4%) women (15). Thus, breastfeeding may contribute to a greater burden of disease among black women. However, none of the studies of breastfeeding and hypertension have included sufficient numbers of black women for informative results (16–21), and only a few of the studies on general metabolic or cardiac health have included this population (22–25).

To address these gaps in the literature, we conducted a nested case-control analysis within a follow-up study of black women to estimate the association between lactation history and incident hypertension, with control for individual metabolic risk factors, health behaviors, and demographic characteristics.

METHODS

Data

We used data from the Black Women's Health Study, a longitudinal cohort study of 59,001 black women enrolled in 1995. Health and demographic data were collected at baseline, and participants complete follow-up questionnaires every 2 years. Ages at enrollment ranged from 21 years to 69 years, with a median age of 38 years. Participants represent all regions of the United States, and almost half (44%) had completed college at the time of recruitment. The most common medical conditions reported at baseline were uterine fibroids, hypertension, high cholesterol, and diabetes (26). Follow-up through the 2013 questionnaire cycle was complete for 87% of person-time.

Measures

Cumulative lifetime lactation. Women answered questions on their lifetime history of lactation in 1995 and 2011. In 1995, participants were asked, "How many months, in total, have you breastfed your children?," with response option categories (in 1995) that included "no children," "never tried," "tried but couldn't," and the following categories of months: <1, 1–3, 4–6, 7–11, 12–17, 18–23, 24–35, 36–47, and ≥ 48 . In 2011, the same question provided a space for participants to fill in the number of months of cumulative lifetime lactation as an integer. Responses for women who answered the questionnaire twice were compared. Based on their responses, the categories for 1995 were collapsed, such that "never tried" and "tried but couldn't" were coded to equal "none" from the 2011 questionnaire, and the category for "less than 1 month" in 1995 was categorized as "1–3 months." The final cumulative lactation variables for 1995 and 2011 contained the following categories in months: none (0), 1–3, 4–6, 7–11, 12–17, 18–23, and ≥ 24 . Cumulative lifetime lactation was ascertained from the response most proximal to the participant's last birth. Reliability of lactation reporting was tested using Cohen's κ coefficient among a subset of 25,142 women who responded to lactation questions at both time points with no intervening births. Responses were similar despite the 16 years between surveys (weighted $\kappa = 0.78$).

Hypertension during middle age. Hypertension in the Black Women's Health Study is defined as a report of antihypertensive medication use or a report of physician-diagnosed hypertension together with use of diuretics in the same questionnaire cycle. For women who already had hypertension at the time of enrollment, hypertension was reported by decade of age (<30, 30–39, 40–49, or ≥ 50 years). Because information on age at diagnosis was not available for these women, we used the following formula to allocate a specific age of onset: Let $A =$ age, $C =$ the category for decade of age of onset, $B =$ the participant's age at baseline, and $Y =$ the youngest age in each category of hypertension onset. The assigned age would thus be

$$A = Y + (1/2(B - Y)).$$

For example, if a participant aged 55 years at baseline reported prevalent hypertension ($B = 55$), with a diagnosis of hypertension at ages 40–49 years ($Y = 40$), then age (A) = $40 + (1/2(55 - 40)) = 47.5$. For instances in which $1/2(B - Y) > 10$, the age at the midpoint of the decade of onset was assigned (i.e., if a participant was aged 65 years at baseline with prevalent hypertension diagnosed at ages 40–49 years, the assigned age would be 45 years).

In follow-up questionnaires, women were asked whether they had been diagnosed with hypertension in the past 2 years and the year of diagnosis. Age at diagnosis, computed from year of diagnosis, was then categorized as follows: 40–44, 45–49, 50–54, 55–59, and 60–65 years.

Covariates. Data on parity and age at last birth were obtained in 1995 and updated with each subsequent questionnaire. Dietary Approaches to Stop Hypertension (DASH) diet score (27), vigorous exercise (none, <3 hours/week, or ≥ 3 hours/week), and pack-years of smoking were ascertained from the baseline questionnaire. Body mass index (BMI) (weight (kg)/height (m)²) in adolescence was derived from recalled weight at age 18 years and baseline height. It was then categorized as either normal (<25) or overweight/obese (≥ 25). Information on education was reported in 1995 and updated in 2003. Histories of pre-eclampsia and gestational diabetes were obtained in 2009. Diabetes was ascertained on each questionnaire, and history of parental diabetes, stroke, or myocardial infarction before or after age 50 years was ascertained at baseline. Parental history of one or more of these conditions was used to determine family history of metabolic disease.

Analytical population. We restricted this analysis to parous women ($n = 44,350$) who had responded to questions about cumulative lifetime lactation ($n = 42,068$). We excluded 7,109 women whose onset of hypertension occurred before age 40 years and 1,012 women who were aged 40 years or more at the birth of their last child. To limit the analytical sample to women who had developed hypertension at ages 40–65 years, we excluded an additional 690 women because they were over age 65 years at the time of diagnosis. This gave us a sampling population of 33,257 women, among whom we identified 12,513 cases of incident hypertension. We used density sampling to frequency-match 2 controls to each case, for a final analytical population of 37,539. Controls were randomly selected from risk sets matched on age and questionnaire cycle. Risk sets included all women who were in the same age category and were disease-free at the time the risk set was sampled. Hypertension cases in the analyses could have occurred as early as 1975; therefore, the risk sets included each 2-year period from 1975 through 1993, as well as from 1995 onward. A single participant could be sampled more than once and could become a case in a later risk set (28). Because we used density sampling for the controls, the odds ratios provide an estimate of the incidence rate ratios that would have been obtained from the full cohort (29, 30).

Statistical analysis

We used unconditional logistic regression to estimate odds ratios and 95% confidence intervals for the association between cumulative lifetime duration of lactation and incident

hypertension. Missing values were handled using complete data analysis (7,455 women excluded).

Potential confounders and effect-measure modifiers were identified through a review of the literature and examination of causal diagrams. Inclusion was based on associations with cumulative lactation among the controls and a greater-than-5% change-in-estimate criterion (31) balanced against an assessment of change in precision (a priori <0.01) calculated using the difference in confidence limit ratios (confidence limit ratio = upper confidence limit/lower confidence limit) (32).

We used likelihood ratio tests to search for effect-measure modification by age, parity, adolescent BMI, and BMI at age 40 years. We performed tests for trend using the midpoint of cumulative lactation in the model as an ordinal variable among women who breastfed. All tests of statistical significance were 2-sided.

Weight retention after pregnancy has been hypothesized as a risk factor for later hypertensive disease. We were therefore interested in whether adult overweight/obesity that developed during the women's reproductive years (defined as ages 18–40 years) more strongly modified the relationship between breastfeeding and hypertension than adolescent BMI. We performed a sensitivity analysis in which this measure of adult BMI, ascertained at age 40 years, replaced our original measure of BMI. This measure was not available for women whose disease occurred prior to completion of the baseline questionnaire, so the analysis was restricted to women who were younger than age 40 years in 1995, had not developed hypertension prior to study entry, and had a BMI less than 25 at age 18 years ($n = 9,214$). In this subset, we assessed the association of breastfeeding with hypertension risk within 3 strata of BMI at age 40 years: <25 , 25–29.9, and ≥ 30 .

It is possible that existing metabolic conditions that are present before pregnancy or that develop during the perinatal period contribute to difficulty with breastfeeding or failed lactation. In a sensitivity analysis using responses available in the 1995 breastfeeding questionnaire, we compared women who “never tried” to breastfeed with those who failed to meet their expectations (“tried but couldn't” or “ <1 month”). For this analysis, we restricted the data set to women who had given birth to their last child prior to the baseline survey ($n = 21,991$).

All analyses were conducted using SAS (version 9.3; SAS Institute, Inc., Cary, North Carolina). The study protocol was approved by the Boston University Institutional Review Board.

RESULTS

Characteristics of participants by duration of lactation among the controls are shown in Table 1. Women with longer durations of breastfeeding were more likely to have had 3 or more children, to have developed preeclampsia, and to have completed college. They also had a healthier diet, exercised more, and smoked less.

Table 2 shows the relationship between cumulative lactation and hypertension in a model that adjusted for the selection factors (age and survey cycle), as well as in a full multivariate model that adjusted for age, survey cycle, parity, age at first birth, diet, exercise, adolescent BMI, smoking, and family history of myocardial infarction. The odds ratio for any breastfeeding versus no breastfeeding in the multivariate-adjusted model was 0.97 (95% confidence interval (CI): 0.92, 1.02; P for trend = 0.37).

In age-specific models (Figure 1), any breastfeeding was associated with reduced risk of hypertension at ages 40–49 years (odds ratio (OR) = 0.92, 95% CI: 0.85, 0.99), and risk decreased with increasing duration of breastfeeding (for ≥ 24 months, OR = 0.82, 95% CI: 0.69, 0.98; P for trend = 0.08). Breastfeeding was not associated with risk of hypertension in women aged 50 years or older, and the P value from a likelihood ratio test comparing results among age groups was 0.02.

There was no effect-measure modification of the relationship between breastfeeding and hypertension by parity ($P = 0.62$) or adolescent BMI ($P = 0.17$). However, in the subset of women for whom we had data on BMI at age 40 years and who had a BMI less than 25 at age 18 years, there was some evidence of effect-measure modification by BMI category ($P = 0.01$). Any breastfeeding was associated with a reduced risk of hypertension in women with BMI <25 at age 40 years (OR = 0.77, 95% CI: 0.65, 0.92) but not among women who were overweight or obese at age 40 years (Table 3).

Women who breastfed for less than 1 month or who failed to lactate (“tried but couldn't”) had approximately the same risk of hypertension as women who “never tried.” Odds ratios were 1.01 (95% CI: 0.90, 1.13) for women who breastfed for less than 1 month and 1.05 (95% CI: 0.97, 1.14) for women who tried but couldn't breastfeed, compared with women who never tried to breastfeed.

DISCUSSION

In this large nested case-control study, we found that breastfeeding was associated with reduced risk of hypertension in women aged 40–49 years. No association was observed for women whose hypertension was diagnosed at ages 50–65 years. Among women aged 40–49 years, the inverse association increased with longer cumulative lactation, and it was strongest among women who breastfed for 24 months or more. Our results support existing evidence for an association between duration of cumulative lifetime lactation and hypertension.

The results of our study additionally support previous cross-sectional research in which the association between lactation and hypertension attenuated with age (18, 21). During the aging process, blood pressure naturally rises due to calcification and stiffening of elastin in the blood vessels (33). Hypertension is a multifactorial disease. It is possible that an association of breastfeeding with reduced risk of hypertension is stronger or present only in younger women because other factors (e.g., calcification) are not playing as great a role at younger ages.

One of the risk factors for hypertension is obesity (3). The risk of obesity, especially central adiposity, increases with increased parity (34–38). The association between lactation and weight retention after pregnancy has been studied extensively, and the results are mixed (39–44). We assessed obesity in 2 ways: 1) by ascertaining adolescent BMI and 2) by adult onset of overweight or obese status at age 40 years. We did not directly assess the association between pregnancy and postpartum weight retention in this study, but previous research among women in the Black Women's Health Study demonstrated greater longitudinal weight gain among women who had children than among those who did not (45) and an inverse association between lactation and postpartum weight retention in women who were normal-weight prior to

Table 1. Demographic Characteristics of Participants (%) According to Cumulative Duration of Lactation in the Control Population ($n = 25,026$), Black Women's Health Study, 1995–2011

Variable ^a	Cumulative Duration of Lactation, months				
	0 ($n = 13,603$)	1–3 ($n = 4,150$)	4–6 ($n = 2,577$)	7–11 ($n = 1,823$)	≥12 ($n = 2,873$)
Age at first birth, years ^b	20 (18–24)	22 (19–27)	23 (19–27)	23 (19–28)	23 (19–28)
Body mass index at age 18 years ^{b,c}	20 (19–23)	20 (19–22)	20 (19–22)	20 (19–22)	20 (19–22)
Parity					
1	34.1	32.8	30.4	20.4	11.8
2	35.8	34.0	40.7	40.3	32.9
3	30.1	33.2	28.9	39.3	55.3
DASH diet score (higher = healthier)					
<19	16.9	14.6	11.6	10.1	10.2
19–22	25.9	23.1	19.2	21.2	18.0
23–25	21.1	21.8	21.5	21.6	20.9
26–28	17.9	20.4	22.6	20.1	23.5
>28	18.2	20.2	25.1	26.9	27.3
Vigorous exercise, hours/week					
0 (none)	44.7	38.7	32.9	32.2	29.9
<3	34.4	39.2	40.5	41.3	40.9
≥3	20.9	22.1	26.7	26.5	29.2
Pack-years of smoking					
0 (never smoker)	53.4	58.6	61.9	59.7	65.6
<20	32.9	30.4	29.7	31.7	29.2
≥20	13.6	11.0	8.5	8.5	5.2
Education					
High school or less	25.7	17.5	13.1	12.7	13.5
Some college	34.4	31.4	27.4	27.3	26.0
College or more	39.9	51.1	59.5	59.9	60.4
Family history of myocardial infarction					
Age <50 years	6.8	6.2	7.1	6.4	5.7
Age ≥50 years	19.9	20.0	17.6	17.7	15.1
Preeclampsia	7.3	6.3	6.6	8.1	8.3
Prevalent diabetes	1.4	1.0	1.2	1.3	0.8

Abbreviation: DASH, Dietary Approaches to Stop Hypertension.

^a Missing data: age at first birth, 1.5%; body mass index at age 18 years, 1.8%; DASH diet score, 8.4%; exercise, 5.1%; pack-years of smoking, 3.1%; education 0.1%; family history of myocardial infarction, 5%; preeclampsia, 30.7%.

^b Values are expressed as median (interquartile range).

^c Weight (kg)/height (m)².

pregnancy (46). Interestingly, we found that the inverse association between cumulative lactation and hypertension was also strongest in normal-weight women. By contrast, in a study of young South Korean women that also stratified results by BMI measured in adulthood, the association was stronger in obese women (19). However, these 2 studies differed in terms of the age of obesity measured, and they also differed in the covariates used and population demographic factors, impeding direct comparison.

To our knowledge, the present study is the first to have assessed the association between cumulative lactation and hypertension by comparing failed lactation with no breastfeeding.

Because of the hormonal complexity of the first few days of breastfeeding, it is possible that simply initiating breastfeeding could change the hypothalamic-pituitary axis (47), thus “turning on” the mechanism that resets metabolic processes. In contrast, underlying hypertensive conditions may make it more difficult to successfully initiate breastfeeding, suggesting the possibility of reverse causality in this subgroup of women. Our results do not demonstrate a difference in the association between failed lactation as compared with never trying to breastfeed and hypertension. Thus, we did not find support for the hypothesis that there is reverse causality (i.e., that breastfeeding difficulties are a marker for underlying hypertension

Table 2. Odds Ratios for Hypertension According to Cumulative Duration of Lactation ($n = 30,084$), Black Women's Health Study, 1995–2011

Duration of Breastfeeding, months	No. of Cases	No. of Controls	Model 1 ^a		Model 2 ^b	
			OR	95% CI	OR	95% CI
None (0)	5,523	10,641	1.00	Referent	1.00	Referent
Any	4,585	9,335	0.95	0.90, 0.99	0.97	0.92, 1.02
1–3	1,649	3,328	0.95	0.89, 1.02	0.96	0.90, 1.03
4–6	1,073	2,112	0.98	0.90, 1.06	1.01	0.93, 1.09
7–11	726	1,513	0.92	0.84, 1.02	0.94	0.86, 1.04
12–17	516	1,018	0.97	0.87, 1.09	0.99	0.88, 1.11
18–23	241	523	0.88	0.75, 1.03	0.90	0.77, 1.06
≥24	380	841	0.87	0.76, 0.98	0.89	0.78, 1.01
<i>P</i> for trend ^c				0.22		0.37

Abbreviations: CI, confidence interval; OR, odds ratio.

^a Model 1 adjusted for age and survey cycle.

^b Model 2 adjusted for age, survey cycle, parity, age at first birth, diet, exercise, body mass index at age 18 years, smoking, and family history of myocardial infarction.

^c *P* for trend was calculated among women who had ever breastfed ($n = 13,920$).

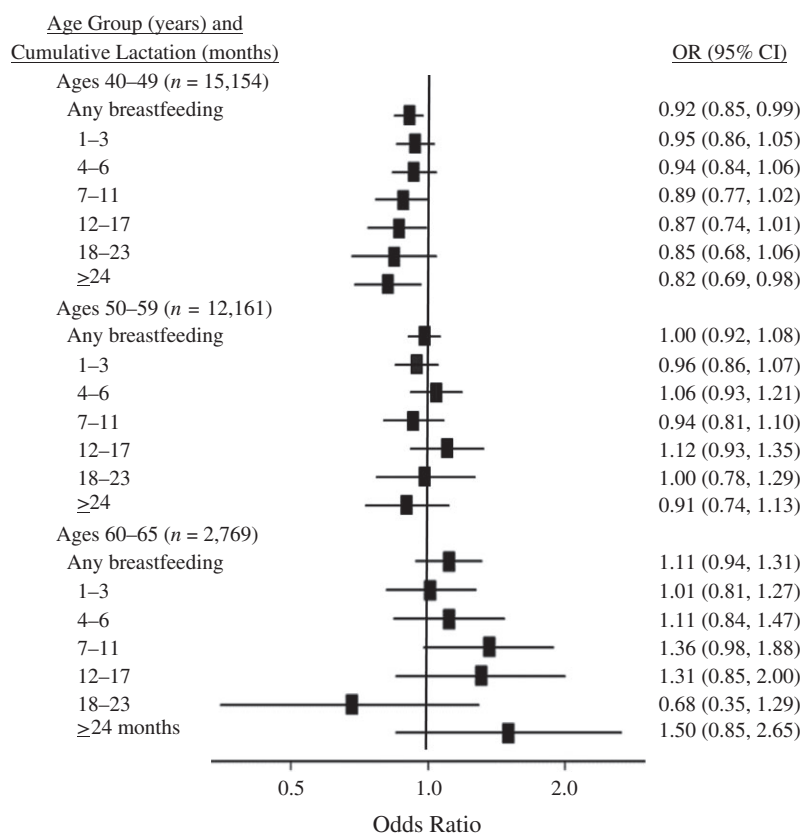


Figure 1. Odds ratios (ORs) and 95% confidence intervals (CIs) for the association between hypertension and cumulative lifetime duration of lactation, for any breastfeeding and by months of lactation, as compared with no breastfeeding among data sets restricted to 3 age groups (40–49, 50–59, and 60–65 years), Black Women's Health Study, 1995–2011. The results were adjusted for age, survey cycle, parity, age at first birth, diet, exercise, body mass index at age 18 years, smoking, and family history of myocardial infarction. *P* for trend among women who breastfed, by age group: ages 40–49 years ($n = 7,342$), *P*-trend = 0.08; ages 50–59 years ($n = 5,510$), *P*-trend = 0.07; ages 60–65 years ($n = 1,068$), *P*-trend = 0.41.

Table 3. Odds Ratios for Hypertension According to Cumulative Duration of Lactation and Body Mass Index at Age 40 Years Among Women Who Developed Hypertension After Baseline (1995) ($n = 9,214$), Black Women's Health Study, 1995–2011^a

Duration of Breastfeeding, months	No. of Cases	No. of Controls	Body Mass Index ^b at Age 40 Years					
			Normal-Weight (<25)		Overweight (25–29.9)		Obese (≥30)	
			OR	95% CI	OR	95% CI	OR	95% CI
None (0)	1,365	2,625	1.00	Referent	1.00	Referent	1.00	Referent
Any	1,668	3,556	0.77	0.65, 0.92	0.99	0.85, 1.15	1.06	0.90, 1.24
1–3	510	1,066	0.86	0.68, 1.09	0.99	0.81, 1.22	0.97	0.78, 1.21
4–6	368	788	0.73	0.56, 0.96	0.95	0.75, 1.19	1.21	0.94, 1.55
7–11	275	618	0.67	0.49, 0.90	1.01	0.78, 1.31	1.04	0.78, 1.38
12–23	341	700	0.83	0.62, 1.20	1.04	0.81, 1.33	1.05	0.81, 1.36
≥24	174	384	0.74	0.52, 1.07	0.96	0.69, 1.33	1.07	0.76, 1.50

Abbreviations: CI, confidence interval; OR, odds ratio.

^a Results were adjusted for age, survey cycle, parity, age at first birth, diet, exercise, body mass index at age 18 years, smoking, and family history of myocardial infarction.

^b Weight (kg)/height (m)².

risk). The wide confidence intervals for our outcomes suggest the need for further research to address this relationship with greater specificity. Additionally, a lack of social or medical support, both of which can reduce breastfeeding rates (48) as well as increase the risk of hypertension (49), cannot be ruled out. Although this population of women had high uptake of prenatal care, hospital postpartum care has been shown to be inconsistently supportive of breastfeeding in communities with higher populations of black women (50), which might also affect observed associations.

Our findings must be interpreted within the limitations of the study design. We were not able to completely compensate for confounding by lifestyle factors, because these factors are incompletely reported, and some were measured at a single point in time. We used cumulative lifetime lactation as the measure of breastfeeding exposure. Our assessment of reliability across a 16-year interval suggested that recalled breastfeeding was reasonably reliable, even decades after the index birth, which is in accord with reports from other studies (51–53). While we had acceptable data on duration of breastfeeding, we did not have data on breastfeeding intensity.

The population of black women we studied is better educated than black women overall in the United States (54), and breastfeeding rates were higher than average rates reported among African-American women in the United States (15). Thus, our results may be less generalizable to black women of lower socioeconomic status or who had lower rates of breastfeeding for other reasons.

One of the strengths of our study was that it utilized cases of hypertension reported by women in the Black Women's Health Study both prior to and after joining the cohort, rather than limiting the analysis to women who developed hypertension after joining the cohort. This approach reduced the potential bias that could have been introduced by ascertaining lactation history retrospectively but excluding all cases of prevalent disease at baseline. This bias would move the point estimate toward the null by eliminating

disease that occurred at younger ages. However, inclusion of these cases introduced imprecision as to the age of diagnosis.

There is a disproportionate burden of hypertension and cardiac disease among black women, who not only have higher disease prevalence but also are affected at younger ages (14). This study contributes to the existing literature on the relationship between breastfeeding and hypertension, extending the results to this understudied and high-priority population. We also contribute methodologically by applying case-control sampling to this literature. Quantifying the association between lactation and hypertension in black women, who have a lower rate of breastfeeding but higher rates and earlier onset of hypertension, underscores the potential benefit of including breastfeeding as a positive health behavior when promoting cardiovascular health. Addressing breastfeeding as a potential preventative health behavior is particularly compelling because it is a modifiable health behavior requiring effort during a discrete period of a woman's life. Future research assessing this relationship would benefit from more specific measures of breastfeeding that account for intensity as well as breastfeeding duration, and from collecting more detailed information on lifestyle factors and perinatal events.

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Author affiliations: Division of Maternal and Child Health, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina (Ellen M. Chetwynd, Alison M. Stuebe, Diane Rowley); Division of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina (Melissa Troester); Division of Maternal and Fetal Medicine, School of Medicine, University of North Carolina at Chapel Hill,

Chapel Hill, North Carolina (Alison M. Stuebe); Slone Epidemiology Center, Boston University, Boston, Massachusetts (Julie R. Palmer, Lynn Rosenberg); and Department of Epidemiology, School of Public Health, Boston University, Boston, Massachusetts (Julie R. Palmer, Lynn Rosenberg).

All authors contributed significantly to the work.

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