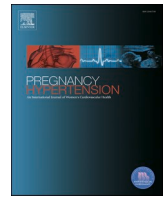


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# Pregnancy Hypertension: An International Journal of Women's Cardiovascular Health

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Short communication

## Sociodemographic risk factors associated with patient follow-up after implementation of a CardioObstetrics program

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### ARTICLE INFO

#### Keywords:

CardioOB  
Cardiovascular disease  
Pregnancy  
Postpartum  
Disparities  
Women's health

### ABSTRACT

Given the association of adverse pregnancy outcomes with risk of developing cardiovascular disease and cardiac events later in life, our institution launched a CardioObstetrics (CardioOB) program aimed to provide long-term care for patients at risk. We performed a retrospective cohort study in order to investigate which patient characteristics were associated with CardioOB follow-up following the inception of the program. We identified several sociodemographic factors and pregnancy characteristics such as increased maternal age, non-English language preferred, married marital status, referral during the antepartum period, and discharged with anti-hypertensive medications after delivery associated with a higher likelihood of CardioOB follow-up.

### 1. Introduction

Several sociodemographic characteristics such as maternal age, race, ethnicity, insurance type, and neighborhood socioeconomic status, have been associated with disparities in obstetric care and contribute to maternal morbidity in the United States. [1–2] Recently, our institution launched a CardioObstetrics (CardioOB) program aimed to provide long-term care for patients at risk of cardiovascular disease and cardiac events following adverse pregnancy outcomes. We set out to investigate which patient characteristics were associated with CardioOB follow-up.

### 2. Methods

This was a retrospective cohort study of all patients who were referred to the CardioOB program within a university health system from the inception of the program in September 2020 until May 2021. The objective of the program is to provide multidisciplinary care aimed at optimizing outcomes in patients with, or at risk of, cardiovascular disease before, during, and after pregnancy. The care team primarily includes health care practitioners from cardiology, obstetrics, and

maternal-fetal medicine. Preconception, prenatal, or postpartum appointments occur separately with each specialty, either in person or via telemedicine. Indications for referral included suspected new or pre-existing cardiovascular disease or dysfunction, or adverse pregnancy outcomes (i.e. preeclampsia with or without severe features, gestational hypertension, and delivery prior to 37 weeks due to fetal growth restriction or spontaneous preterm birth). Although a standard workflow is used by patient navigators when scheduling appointments (Fig. 1), providers may individualize follow-up based on clinical evaluation as they see fit. Patients with previously established cardiology care and missing delivery data were excluded. Several sociodemographic and pregnancy-related factors were compared between two groups: patients who presented for their CardioOB appointment (i.e. CardioOB follow-up) versus those who did not (i.e. no CardioOB follow-up) (See Table 1). Patient Zone Improvement Plan (ZIP) codes were linked to neighborhood-level data from the United States Census Bureau's American Community Survey. [3] Statistical analysis included use of chi-squared test and Student's *t* test for comparisons of categorical and continuous variables. Multivariable logistic regression was used to evaluate factors associated with CardioOB program follow-up. Data

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<https://doi.org/10.1016/j.preghy.2023.02.004>

Received 5 December 2022; Received in revised form 2 February 2023; Accepted 13 February 2023

Available online 18 February 2023

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were presented as adjusted odds ratios (aOR) with 95 % confidence intervals (95 % CI) and statistical significance set at  $P < 0.05$ . An institutional review board approval was obtained.

### 3. Results

During the study period, a total of 454 patients were referred to the CardioOB program. After excluding patients with previously established cardiologic care ( $n = 40$ ) and missing delivery data ( $n = 3$ ), 411 patients comprised the study cohort and were further analyzed. Of those, 226 (55 %) followed up with their scheduled CardioOB visit, while 185 (45 %) did not. Baseline characteristics compared between the two groups are displayed in Table 1. Sociodemographic factors associated with a higher likelihood of CardioOB follow-up included increased maternal age (aOR 1.08, 95 % CI 1.03–1.13), married marital status (aOR 2.02, 95 % CI 1.14–3.58), non-English language preferred (aOR 2.96, 95 % CI 1.14–7.69) (Table 2). Patients referred to CardioOB during the antepartum period (aOR 4.56, 1.60–12.99) and those discharged with antihypertensive medications after delivery (one medication: aOR 2.18, 95 % CI 1.19–3.99; two medications: aOR 3.15, 95 % CI 1.11–8.90) were also more likely to follow-up with CardioOB (Table 2). Neighborhood living with a higher median household size was associated with a higher likelihood of no CardioOB follow-up (aOR 3.03, 95 % CI 1.10–8.33) (Table 2). Maternal race, ethnicity, and insurance type were not associated with a change in likelihood of follow-up (Table 2). Although patients in the CardioOB follow-up group were more commonly referred to the program for suspected new or pre-existing cardiovascular disease and less commonly referred for hypertensive disorders of pregnancy, the indication for CardioOB referral was not associated with a change in likelihood of CardioOB follow-up after adjusting for potential confounders.

### 4. Discussion

After implementation of our CardioOB program, overall patient follow-up was relatively low. We identified several sociodemographic factors and pregnancy characteristics associated with CardioOB follow-up. We hypothesize that maternal age, marital status, and neighborhood median household size likely play a role in access to care and patient availability for prenatal and postpartum appointments. Furthermore, the increased follow-up among patients referred to CardioOB during pregnancy and discharged with antihypertensive medications postpartum may reflect their understanding of the immediate health impact

of their condition and lack of prioritizing long-term care. Similarly, more common indications for follow-up included suspected new or pre-existing cardiovascular disease rather than adverse pregnancy outcomes associated with developing cardiovascular disease or cardiac events later in life, which may reflect patients willingness to follow-up on a medical condition they already have versus one they may develop at a later time. Despite efforts to educate patients with adverse outcomes such as hypertensive disorders of pregnancy regarding the risk of developing long-term cardiovascular disease or cardiac events later in life during referral and counseling on the objectives of our program, future research exploring additional interventions aimed at patient education should be considered and may improve follow-up. Quality improvement projects dedicated to increasing patient and provider education, as well as patient access to care, have been associated with improved adherence to follow-up during the postpartum period in patients with hypertensive disorders. [4–5] The independent association of non-English language preferred patients with CardioOB follow-up was surprising, as language has been identified as a barrier to obtaining medical care. [6].

The majority of patients in our cohort were referred to CardioOB during their delivery hospitalization due to adverse pregnancy outcomes associated with increased cardiovascular disease risk. [7] Due to the recent implementation of the CardioOB program, we were unable to evaluate the incidence of cardiac events following these outcomes and whether higher follow-up rates reduce such risks. Furthermore, patient follow-up may have been low due to our program being new and unfamiliar to our patients. Lastly, we were unable to control for the referring provider type, which may have contributed to our findings. While multidisciplinary care with CardioOB has been associated with improved maternal outcomes during pregnancy and low postpartum readmission rates, [8] future research exploring the long-term benefits are needed. Nevertheless, these data may be useful in developing strategies aimed to increase follow-up and provide care for patients in this select population. Future efforts from our program include having cardiology, obstetrical, and maternal-fetal medicine providers together in clinic evaluating patients, integrating digital platforms and machine learning to facilitate and coordinate follow-up, and conducting quality improvement studies aimed at improving patient follow-up. These efforts may assist in issues of health inequity and would serve to customize the approach to patients.

TIMELINE FOR APPOINTMENT BY INDICATION:					
1 - Underlying/pre-existing cardiac disease for pre-conception consult or already pregnant:		2 - ADVERSE PREGNANCY OUTCOME:			
		<ul style="list-style-type: none"> <li>• Preeclampsia or gestational hypertension in pregnancy or postpartum</li> <li>• Prior spontaneous preterm birth (labor or ruptured membranes) before 37 weeks</li> <li>• History of growth restricted fetus requiring preterm delivery before 37 weeks</li> </ul>			
		"URGENT"*		NOT "URGENT"	
PREGNANT: within 2 weeks of referral request	NOT PREGNANT: within 8 weeks of referral request	PREGNANT – within 2 weeks of referral request	NOT PREGNANT –  POSTPARTUM + DELIVERED WITHIN THE PAST 6 WEEKS – within 4 weeks of delivery date  PRECONCEPTION – within 4 weeks of referral request	PREGNANT – 8 weeks after due date	NOT PREGNANT –  POSTPARTUM + DELIVERED WITHIN THE PAST 6 WEEKS – 8 weeks after delivery date  PRECONCEPTION: within 8 weeks of referral request

\*Patient considered "URGENT" if seen by a cardiologist inpatient for severe features or cardiac concerns during current / recent pregnancy.

Fig. 1. Standardized workflow for scheduling patient follow-up with CardioObstetrics.

**Table 1**  
Baseline characteristics compared between the two groups.

	Follow-up with CardioOB (n = 226)	Did not follow-up with CardioOB (n = 185)	P value
Maternal age (y)	33.7±5.5	31.9±5.6	0.001
Body mass index (kg/m <sup>2</sup> )	34.2±6.8	33.2±6.9	0.1
Race			0.06
Asian	26 (11.5)	37 (20.0)	
Black	55 (24.3)	39 (21.1)	
White	66 (29.2)	57 (30.8)	
Other/multiracial	70 (31.0)	50 (27.0)	
Unknown	9 (4.0)	2 (1.1)	
Ethnicity			0.1
Hispanic	59 (26.1)	33 (17.8)	
Non-Hispanic	162 (71.7)	149 (80.5)	
Other	5 (2.2)	3 (1.6)	
Single	51 (22.6)	68 (36.8)	0.002
Non-English language preferred	31 (13.7)	13 (7.0)	0.03
Public health insurance	92 (40.7)	79 (42.7)	0.7
Neighborhood characteristics			
Median annual household income, \$	50,153±18,900	51,200±21,979	0.6
Education less than high school, %	10.8±6.9	10.8±7.4	1
Unemployment, %	5.2±2.2	5.2±2.1	0.8
Households receiving supplemental income, %	16.5±13.6	16.4±12.1	0.9
Single parent household, %	27.1±16.3	26.0±15.4	0.5
Median household size	3.0±0.4	3.1±0.4	0.05
Owner occupied housing, %	63.6±22.1	64.9±20.9	0.5
Nulliparous	114 (50.4)	95 (51.4)	0.9
Chronic hypertension	71 (31.4)	22 (11.9)	<0.0001
Vaginal delivery	85 (37.6)	85 (45.9)	0.09
Indication for CardioOB referral			<0.0001
Suspected new cardiac disease/dysfunction	17 (7.5)	3 (1.6)	
Known pre-existing cardiac disease	54 (23.9)	15 (8.1)	
PEC with severe features/HELLP	95 (42.0)	88 (47.6)	
PEC without severe features or gHTN	47 (20.8)	71 (38.4)	
Other risk factors	13 (5.8)	8 (4.3)	
Time of CardioOB referral			<0.0001
Antepartum	73 (32.3)	15 (8.1)	
Delivery hospitalization	113 (50.0)	130 (70.3)	
Postpartum	40 (17.7)	40 (21.6)	
Gestational age at delivery (wk)	36.5±4.0	37.2±3.7	0.06
Oral antihypertensive therapy at discharge			<0.0001
None	85 (37.6)	119 (64.3)	
1 medication	101 (44.7)	58 (31.4)	
2 medications	24 (10.6)	8 (4.3)	

Data presented as mean (±standard deviation) or number (percentage).

**Declaration of Competing Interest**

The authors declare that they have no known competing financial

**Table 2**  
Factors associated with follow-up and no follow-up with CardioObstetrics.

	Adjusted OR with 95 % CI	P value
Factors associated with follow-up		
Maternal age	1.08 (1.03–1.13)	0.002
Marital status: married	2.02 (1.14–3.58)	0.03
Language preferred: Non-English	2.96 (1.14–7.69)	0.02
Referred during antepartum	4.56 (1.60–12.99)	0.004
Discharged with one antihypertensive medication after delivery	2.18 (1.19–3.99)	0.01
Discharged with two antihypertensive medication after delivery	3.15 (1.11–8.90)	0.03
Factors associated with no follow-up		
Neighborhood median household size	3.03 (1.10–8.33)	0.03
Factors that were not associated with or without follow-up		
Race: White	1.59 (0.75–3.38)	0.2
Race: Black	2.29 (0.92–5.69)	0.07
Race: Other/Multiracial	1.67 (0.68–4.13)	0.3
Ethnicity: Hispanic	1.91 (0.81–4.51)	0.1
Insurance type: Public	0.33 (0.02–4.97)	0.4
Insurance type: Private	0.38 (0.03–5.83)	0.5
Referred due to suspected new cardiac disease/dysfunction	2.01 (0.34–11.73)	0.4
Referred due to known pre-existing cardiac disease	0.65 (0.13–3.37)	0.6
Referred due to preeclampsia with severe features/HELLP	0.58 (0.17–2.05)	0.4
Referred due to preeclampsia without severe features or gHTN	0.53 (0.16–1.81)	0.3

Reference groups for marital status is single, language preferred is English, race is Asian, ethnicity is non-Hispanic, insurance type is self-pay, time of CardioObstetrics referral is delivery hospitalization, indication for CardioObstetrics referral is other risk factors, and discharge with medications after delivery is none.

Other variables included in the model that were not significant: body mass index, neighborhood characteristics (median annual household income, education less than high school, unemployment, households receiving supplemental income, single parent household, owner occupied housing), parity, chronic hypertension, mode of delivery, and preterm delivery.

interests or personal relationships that could have appeared to influence the work reported in this paper.

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