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Birth-Related Outcomes for Second Children Following Home Visiting Program Enrollment for New Parents of First Children

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Abstract

Introduction Home visiting (HV) programs aim to promote child and family health through perinatal intervention. HV may benefit second children through improving subsequent pregnancy and birth outcomes. However, HV impacts on birth outcomes of second children have not been examined in a naturalistic setting.

Methods Using data from Connecticut Nurturing Families Network (NFN) home visiting program of families enrolled from 2005 to 2015, we compared birth-related outcomes (birthweight, preterm birth, Cesarean section delivery, prenatal care utilization) of second children (n = 1758) to demographically similar propensity-score-matched families that were not enrolled in NFN (n = 5200). We examined whether the effects of NFN differed by maternal age, race and ethnicity, or visit attendance pattern.

Results There was no program effect for the full sample. The effect of NFN did not differ by maternal age or visit attendance pattern but did differ by maternal race and ethnicity. Black women in NFN were more likely to receive adequate prenatal care during their second pregnancy (OR 1.05; 95% CI 1.01, 1.09) and Hispanic women in NFN were less likely to deliver by Cesarean section for their second birth (OR 0.97; 95% CI 0.94, 0.99), compared to Black and Hispanic women in the comparison group respectively. There was a protective program effect on prematurity of the second child (OR 0.92; 95% CI 0.85, 0.996) for women with a preterm first birth.

Discussion These findings suggest that benefits of HV extend to subsequent birth-related outcomes for women from marginalized racial/ethnic groups. HV may help buffer some harmful social determinants of health.

Keywords Home visiting · Gestational age · Birth weight · Cesarean section · Prenatal care · Home visiting

Significance Statement

What is already known on this subject? Home visiting has shown long-term positive outcomes for mothers and first children, but only limited positive effects on birth outcomes. *What this study adds?* Program effects were not detected for the full sample. However, home-visited Black women were less likely to begin prenatal care late for their second pregnancy than comparison group Black women. Home-visited Hispanic women were less likely to deliver their second child by Cesarean section than comparison group Hispanic women. Therefore, home visiting can improve some birth

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outcomes for subsequent children, but more information is needed to explain these findings and to determine if program changes could bring about broader impact.

Introduction

Home visiting (HV) programs aim to improve the health of children and families during pregnancy and following birth by providing education, social support, and connections to health and social services (Olds et al., 2007). HV programs often target first-time parents, as benefits of HV are hypothesized to improve outcomes for subsequent children (Olds et al., 1999). However, the effects of HV on birth outcomes for second children have not been well studied (Goyal et al., 2016; Rubin et al., 2011).

Birth outcomes are important for maternal and child health, and child development (Barker et al., 1993; Boyle et al., 2012; Curtin et al., 2015). Healthy People 2020 goals include reducing the incidence of low birthweight, preterm birth, and Cesarean section (C-section) for low-risk births; and increasing the proportion of families receiving adequate prenatal care (Centers for Disease Control & Prevention, 2013). Improving birth outcomes is particularly important for women and children at risk for health inequities. In the United States (US), Black and Hispanic women are at higher risk for poor birth-related outcomes compared to white women, including low birthweight, preterm birth, C-section, and late prenatal care initiation (Flores et al., 2012; Gadson et al., 2017; Thoma et al., 2019). As race is socially constructed, these inequities are not attributable to biological or genetic differences, but are the effects of interpersonal, institutional, and structural racism (Dominguez et al., 2008; Gadson et al., 2017).

Mothers younger than 18 years are at increased risk for preterm birth, low birthweight, and later initiation of prenatal care (Harrison et al., 2019; Wiemann et al., 1997). HV may attenuate some social determinants of health inequities by targeting moderating factors contributing to disparities among individuals of color (e.g., access to healthcare; Harvey et al., 2017; Lee et al., 2009) and of young maternal age (e.g., social support; Robling et al., 2016; Sangalang, 2006). These strategies may contribute to improvements in subsequent pregnancies, such as a reduced risk of low birthweight for the second child if the first child was born with low birthweight (Holland et al., 2018).

Nurturing Families Network

Nurturing Families Network (NFN) is a statewide, voluntary HV program in Connecticut. NFN uses a Maternal, Infant, and Early Childhood Home Visiting (MIECHV, a federal funding program) supported curriculum, *Parents as Teachers* (Parents as Teachers, n.d.).[1] First-time mothers are recruited based on program availability and risk for child maltreatment. Home visitors are paraprofessionals with at least a high school diploma; home visitor supervisors hold a master's degree, often in social work. Although program recruitment frequently takes place in hospitals after birth, recruitment may occur during pregnancy up to the child's third month of life. Frequency of home visits varies based on family needs; visits are offered until the child is 5 years old. Visits generally occur every 2 weeks (Holland, 2019; Joslyn et al., 2016).[2]

Current Study

The purpose of this study is to examine the effects of NFN on birth outcomes for second children and to test whether effects are moderated by maternal race and ethnicity or maternal age. We hypothesized that NFN participation improves birth outcomes for second children, particularly for women of color and young maternal age.

Methods

We utilized a retrospective cohort design to compare birth outcomes of NFN second children with those of a comparison group. The NFN second child group consisted of second-born children of mothers who enrolled in NFN for their firstborn. The comparison group included second children propensity-score-matched (PSM) to NFN second children based on families' demographic and neighborhood characteristics. The purpose was to provide a large, demographically similar group to compare to NFN program families. Details on the creation of this comparison group are reported elsewhere (Holland, 2019, 2021).

Data Sources

We linked three administrative data sources: NFN data, Connecticut birth certificate data, and the American Community Survey (U.S. Census Bureau, 2009). This project was

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[1] NFN was restructured in 2019 and is now called the Connecticut Home Visiting System.

[2] As of this writing, these visits are being conducted by phone or video visits due to COVID-19.

conducted in partnership with two state agencies, Connecticut Department of Public Health (DPH) and Office of Early Childhood (OEC). Yale University, University of Hartford, and each state agency granted Institutional Review Board approval. The research was conducted in accord with prevailing ethical principles.

The University of Hartford Center for Social Research provided program data on mothers enrolled in NFN from 2005 to 2015 who consented to research participation. DPH provided birth certificate data (2005–2015) including individual identifiers, birth outcomes, demographics, and geographic identifiers. The American Community Survey (2005–2009) provided information on neighborhood characteristics used to create summary variables which were standardized across all census tracts (Holland, 2021). Summary variables included residential stability (median income, percentages of housing units owner-occupied, percentages of residents living in the same house one year ago), concentrated poverty (number of residents in poverty, receiving public assistance, headed by single women), and Hispanic-enclave character (percentages of Spanish-speaking households, limited English proficiency households, Puerto Rican residents).

Creating Intervention and Comparison Group

Participants enrolled in NFN were linked to first births in the Connecticut Birth Certificate data based on identifying characteristics (e.g., dates of birth). The NFN second children group was created by identifying birth order in mother–child dyads. Of 7400 NFN enrolled families, there were 4822 NFN first live births who were linked with birth certificates, 2973 of whom did not have a second birth. Our final sample included 1849 NFN second children. PSM families were matched to NFN families using 3:1 propensity-score matching. We tested for equivalence between the PSM and NFN groups (Table 1). Differences between groups were insubstantial, suggesting successful matching. Our final representative cohort included 5420 PSM children.

Measures

Birth-Related Outcomes

We examined four birth-related outcomes: adequacy of prenatal care, C-section, birthweight, and gestational age. We created a dichotomous variable to assess adequacy of prenatal care based on initiation timeframe: adequate (initiated in months 1–4 or first trimester if month was not available) or inadequate (prenatal care initiated in months 5–9, none, or third trimester). We chose this threshold based on the Kotelchuck Adequacy of Prenatal Care Utilization Index which uses both number of visits and timing, but categorizes

utilization after the fourth month as inadequate regardless of number of visits (Kotelchuck, 1994); we did not have access to reliable data on the number of visits. We created dichotomous variables to assess birthweight (low < 2500 g; normal ≥ 2500 g) and preterm status (preterm < 37 weeks; term ≥ 37 weeks). We also examined distribution of birthweight as a continuous variable and used the Kolmogorov–Smirnov test (Kaplan, 2019) for differences between distributions by group. We reviewed data for implausible birthweight and gestational age combinations (Talge et al., 2014).

Mother's Age at First Birth

We created five maternal age categories based on developmental stages: 12–16 years (young teenagers), 17–18 years (transitional teens), 19–21 years (older adolescents), 22–25 years (emerging adults), and 26–34 years (young adults) (Arnett, 2000; Phipps & Sowers, 2002; World Health Organization, 2014). We excluded older women from analyses due to small sample size (n = 277, 3.8%) and biological differences (Society for Maternal-Fet al., & Medicine, 2014).

Mother's Race and Ethnicity

Mothers' self-identified race and ethnicity were obtained from the first child's birth certificate. We categorized race and ethnicity as non-Hispanic white, non-Hispanic Black, Hispanic, Asian, or Other/Unknown. Due to small numbers, mothers who self-identified as American Indian (< 1%) were categorized as Other/Unknown.

Analysis

Analyses were conducted using SAS 9.4® and Stata 15. We used logistic regression for primary models. In C-section models, we excluded mothers who delivered their first birth by C-section due to inconsistent clinical availability of vaginal birth after cesarean. We examined maternal age and race and ethnicity independently as moderators of the effect of NFN on each outcome. Participants who were classified as "Other/Unknown" (n = 83; 1.2%) or Asian (n = 133; 1.9%) were excluded from race and ethnicity interaction analyses, because cell sizes were too small. For age interaction models, we created a new category of 16-, 17-, and 18-year-old mothers to increase cell size and omitted those less than 16 years old due to developmental differences. We tested an interaction between intervention group and child sex; however, we excluded it from final models because it was not statistically significant. To assess clinical relevance of

Table 1 Description of sample

	Propensity-Score Matched (N = 5200)	NFN Second Children (N = 1758)	p-value
Mother's characteristics			
Maternal age, mean (SD)	23 (3.9)	23 (3.9)	0.29
Categorical mother age, N (%)			0.14
12–16	31 (0.6%)	21 (1.2%)	
17–18	302 (5.8%)	101 (5.7%)	
19–21 (reference)	1540 (29.6%)	516 (29.4%)	
22–25	1967 (37.8%)	677 (38.5%)	
26–34	1360 (26.2%)	443 (25.2%)	
Mother's Highest Level of Education, N (%)			0.36
Grades 1 through 11	1671 (32.3%)	545 (31.2%)	
High School Equivalent, 12th Grade	2102 (40.6%)	742 (42.5%)	
College level, less than 4 years	1110 (21.4%)	372 (21.3%)	
College level, 4 years	182 (3.5%)	47 (2.7%)	
College level, 5 or more years	111 (2.1%)	39 (2.2%)	
Race & Ethnicity			0.02*
White	1298 (25.0%)	386 (22.0%)	
Black	1056 (20.3%)	387 (22.0%)	
Asian	68 (1.3%)	15 (0.9%)	
Hispanic	2673 (51.4%)	942 (53.6%)	
Other/Unknown	105 (2.0%)	28 (1.6%)	
Mother born in the US	3564 (68.8%)	1188 (67.9%)	0.46
Connection with Partner[a]	3921 (75.4%)	1273 (72.5%)	0.01*
Diabetes (Preexisting/Gestational)	219 (4.2%)	76 (4.3%)	0.85
Private Insurance[b]	802 (15.4%)	218 (12.5%)	0.002
Child characteristics			
Male	2666 (51.3%)	898 (51.1%)	0.89
Multiple Gestation (twin, triplet, etc.)	77 (1.5%)	20 (1.1%)	0.29
Neighborhood characteristics			
Concentrated poverty, mean (SD)[c]	0.84 (1.22)	0.97 (1.31)	< 0.001***
Hispanic enclave, mean (SD)[c]	0.77 (1.21)	0.82 (1.32)	0.15
Residential stability, mean (SD)[c]	− 0.76 (.86)	− 0.82 (0.91)	0.008**
Birth outcomes			
Prenatal Care by 5 months	4634 (89.9%)	1556 (89.7%)	0.82
Prenatal Care trimester of initiation			0.97
Months 1 to 3	4112 (79.8%)	1396 (80.3%)	
Months 4 to 6	917 (17.8%)	300 (17.3%)	
Months 7 to 8	106 (2.1%)	36 (2.1%)	
No prenatal care	21 (0.4%)	7 (0.4%)	
Cesarean section delivery[d]	116 (9.02%)	398 (10.0%)	0.28
Birthweight			0.88
Very low birthweight (< 1000 g)	69 (1.33%)	27 (1.54%)	
Low birthweight (< 2500 g, ≥ 1000 g)	304 (5.86%)	100 (5.7%)	
Normal birthweight	4473 (86.15%)	1511 (86.1%)	
High birthweight (> 4000 g)	346 (6.66%)	117 (6.67%)	
Preterm (< 37 weeks)	342 (6.6%)	117 (6.7%)	0.91

[a]Married, father on birth certificate, same sex partner

[b]Insurance type used for Prenatal Care and/or Delivery; as compared to public, self-pay, other

[c]Standardized version of American Community Survey factors

[d]Includes only those with vaginal first births, N = 5250 (NFN N = 1286, PSM N = 3964)

*p < 0.05, **p < 0.01, ***p < 0.001

any significant findings, we estimated predicted values for each group, which were probabilities for dichotomous and categorical variables.

Covariates

We controlled for variables that were statistically non-equivalent between the two groups (mother's race, concentrated poverty, residential stability, private insurance, connection with partner). If there was evidence of misspecification, two-way interactions between covariates were added to the model. Covariates differed based on the model (Tables 2 and 3).

Sensitivity Analyses

Alternative Variable Formats For each outcome except C-section, we examined a format of the variable with more categories. We used ordered logistic regression for prenatal care initiation by trimester (3 trimesters and no prenatal care) and low birthweight with a separate very low birthweight category (<1000 g; high birthweight children [>4000 g; n=500, 6.8%] were excluded because high birthweight may result from different mechanisms such as maternal diabetes); both passed tests for proportional odds. For gestational age, we treated the number of weeks < 39 as a count variable and used negative binomial regression; this model fit better than Poisson or zero-inflated models based on the Akaike Information Criterion.

Visit Attendance Patterns To determine if NFN program dose was associated with birth outcomes, we created visit attendance patterns using repeated measures latent class analysis (Lanza & Collins, 2008; *PROC LCA & PROC LTA (Version 1.3.2)*, 2015). Families were clustered based on the number of completed home visits each month and when the family stopped receiving visits or dropped out. Five resulting classes, ranging from lowest dose of the program to highest, were defined as "Low Attendance," "Early Exit 1," "Early Exit 2," "Early Exit 3," and "Sustained Attendance" (see Online Appendix A for details). We examined whether these classes moderated relationships found in the primary and secondary models.

Program Engagement During Second Pregnancy To determine if continued engagement with the program was associated with variations in second birth outcomes, we included an interaction with an indicator of NFN visits during the second pregnancy. C-section delivery was excluded from this sensitivity analysis because only 18 women were engaged in NFN at the time of the second birth and delivered their second, but not first, child by C-section.

NFN First Children As a secondary comparison group, we used children whose birth led to enrollment of their mothers in NFN (n = 1849). The purpose of the NFN first-child group was to control for unmeasured factors (e.g., genetics) and determine if findings from PSM analyses were consistent when comparing NFN second children to a different group. However, a limitation of this comparison group was that birth order effects influence birth outcomes. We used the difference-in-differences approach to utilize PSM first and second children as controls for this effect.

Differential Program Effect To determine if the program effect was different for mothers with a previous *concerning* birth outcome (low birthweight or preterm birth), we tested interactions between program enrollment and these outcomes for first children in models for the same outcomes at the second birth.

Missing Values

Few values were missing in our key variables (<1%). Those with the greatest percentage missing were the American Community Survey characteristics (5.7% missing). These values were missing in the data source, which was not related to the families' characteristics. We therefore considered these missing completely at random and used complete case analysis. The final analysis sample included 1758 NFN families and 5200 PSM families.

Results

Most women in NFN delivered their first child when they were age 25 or younger and the majority completed no more than a high school education (Table 1). About half of the sample identified as Hispanic and one-fifth as Black. Women not included in these analyses because they did not have a second child within the study timeframe were less likely to be Hispanic (p < 0.001); completed more education (p < 0.001); and were more likely to be born outside of the US but less likely to be born in a US territory (p = 0.007; Supplemental Table 1).

Most women began prenatal care in the first three months of their second pregnancy (NFN: 90.0%, PSM: 89.8%; p = 0.81). Program involvement was not associated with prenatal care in the base model (OR 1.05; 95% CI 0.87, 1.27) nor when an interaction with age was included (Table 2). However, an interaction with race and ethnicity was significant. Black women in NFN were more likely to receive prenatal care before the fifth month of pregnancy than Black women in the comparison group (OR 1.05; 95% CI 1.01, 1.09; Tables 3, 4, and Fig. 1a); Black women in NFN were predicted to have an 89.3% probability of receiving prenatal care by the fifth month and Black women in the comparison group were predicted to have an 84.8% probability.

Similar proportions of NFN and PSM second children were delivered by C-section (9.0% and 10.0%; p = 0.28) in

Table 2 Associations between program enrollment and birth outcomes including an interaction with maternal age at first birth in logistic regression models

	Prenatal care by 5 months[a,b]		Cesarean section[a,c]		Low birthweight[a,d]		Preterm birth[a,e]	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Program enrollment	1.05 (0.76, 1.46)		1.03 (0.66, 1.60)		0.81 (0.52, 1.28)		0.85 (0.57, 1.26)	
Age		0.15		0.66		0.99		0.47
16 to 18[f]	0.89 (0.71, 1.11)		0.88 (0.51, 1.52)		0.99 (0.73, 1.37)		1.02 (0.78, 1.32)	
19 to 21	Ref		Ref		Ref		Ref	
22 to 25	1.20 (0.88, 1.64)		1.30 (0.68, 2.49)		0.98 (0.61, 1.29)		1.28 (0.93, 1.76)	
26 to 34	1.23 (0.84, 1.80)		0.83 (0.35, 2.00)		1.06 (0.58, 1.35)		1.03 (0.69, 1.54)	
Program × age interaction		>0.99		0.31		0.58		0.72
16 to 18	1.02 (0.66, 1.59)		0.94 (0.50, 1.77)		1.51 (0.83, 2.79)		1.34 (0.80, 2.25)	
19 to 21	Ref		Ref		Ref		Ref	
22 to 25	0.99 (0.53, 1.84)		0.93 (0.44, 1.95)		1.22 (0.60, 2.68)		1.30 (0.69, 2.46)	
26 to 34	0.96 (0.46, 1.97)		2.25 (0.87, 5.81)		1.09 (0.44, 2.55)		1.14 (0.52, 2.47)	
Program effect, by age[g]								
16 to 18	1.01 (0.98, 1.04)		1.00 (0.97, 1.03)		1.01 (0.99, 1.04)		1.01 (0.98, 1.04)	
19 to 21	1.00 (0.98, 1.03)		1.00 (0.96, 1.03)		0.99 (0.97, 1.01)		0.99 (0.97, 1.01)	
22 to 25	1.00 (0.97, 1.04)		1.00 (0.95, 1.06)		1.00 (0.97, 1.03)		1.01 (0.97, 1.05)	
26 to 34	1.00 (0.96, 1.04)		0.92 (0.86, 0.99)[h]		1.00 (0.96, 1.03)		1.00 (0.96, 1.04)	

[a]All models include the following covariates: mother's race, concentrated poverty, residential stability, private insurance, connection with partner. Additional covariates vary by model, as noted below

[b]Covariates: all for the first child/pregnancy—diabetes, sex, adequate prenatal care, C-section delivery, birthweight, extremely premature (<22 weeks)

[c]Covariates: all of the second child/pregnancy—sex of the child, diabetes, congenital anomalies, multiple births, mother's race

[d]Covariates: for the first child/pregnancy—diabetes, sex of the child; for the second child/pregnancy—sex of the child, diabetes, congenital anomalies, multiple births

[e]Covariates: for the first child/pregnancy—diabetes, sex of the child, C-section delivery, preterm status; for the second child/pregnancy—sex of the child, diabetes, congenital anomalies

[f]Maternal age at first birth: 12- to 15-year-old mothers are not included in these models due to the small number of women in these groups. We did not include them in the same category as 16- to 18-year-olds because they are in different stages of physical and social development

[g]Compared to propensity-score-matched group

[h]Although this individual confidence interval indicates a significant association, the overall joint test for the interaction is not significant

*p<0.05; **p<0.01; ***p<0.001

families of first children born by vaginal delivery. There was no program effect in the base model (OR 0.86; 95% CI 0.68, 1.12) nor when an interaction with age was included (Table 2). With the race interaction, program enrollment was associated with a lower likelihood of C-section for second children of Hispanic women (OR 0.97; 95% CI 0.94, 0.99; Table 3 and Fig. 1b); Hispanic women in NFN had a predicted probability of C-section of 5.3% and Hispanic women in the comparison group had a predicted probability of 8.9%.

Similar proportions of second children in each group were born with low birthweight (NFN: 6.0%, PSM: 5.7%; p=0.61). Low birthweight was not associated with program involvement in the base model (OR 1.02; 95% CI 0.80, 1.30) nor when interactions with age or race and ethnicity were included (Tables 2 and 3). There was no significant difference in distribution of birthweights by group (p=0.12);

Supplemental Fig. 1 confirms there was no meaningful difference.

Preterm birth rates were similar across groups (NFN 8.4%, PSM: 8.3%; p=0.88). Preterm birth was not associated with program enrollment overall (OR 1.01; 95% CI 0.82, 1.26), nor when age or race and ethnicity interactions were added to the model.

Sensitivity Analyses

Sensitivity analysis examining different variable formats showed no substantial differences in results. When we replaced program enrollment with visit attendance patterns in our models to evaluate the role of dose, the few statistically significant associations did not follow logical patterns and were likely spurious given the number of comparisons

Table 3 Associations between program enrollment and birth outcomes including an interaction with maternal race and ethnicity at first birth in logistic regression models

	Prenatal care by 5 months[a,b]		Cesarean section[a,c]		Low birthweight[a,d]		Preterm Birth[a,e]	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Program enrollment	0.79 (0.27, 0.52)		1.21 (0.73, 2.00)		0.91 (0.50, 1.63)		1.4 (0.88, 2.21)	
Race		< 0.001		0.57		0.46		0.43
Non-Hispanic White	Ref		Ref		Ref		Ref	
Non-Hispanic Black	0.55 (0.41, 0.74)***		1.22 (0.83, 1.80)		1.27 (0.85, 1.90)**		1.26 (0.89, 1.81)	
Hispanic	0.86 (0.65, 1.13)*		1.06 (0.77, 1.46)		1.08 (0.76, 1.54)		1.17 (0.86, 1.59)	
Program × race interaction		0.03		0.03		0.52		0.25
Program × White[f]	Ref		Ref		Ref		Ref	
Program × Black[f]	1.99 (1.13, 3.51)***		1.02 (0.52, 2.07)		1.43 (0.68, 3.01)		0.76 (0.41, 1.42)	
Program × Hispanic	1.18 (0.72, 1.93)**		0.48 (0.25, 0.91)*		1.07 (0.54, 2.11)		0.63 (0.36, 1.09)	
Program effect, by race[g]								
Non-Hispanic White	0.98 (0.95, 1.02)		1.02 (0.97, 1.06)		0.996 (0.97, 1.02)		1.02 (0.99, 1.05)	
Non-Hispanic Black	1.05 (1.01, 1.09)*		1.02 (0.97, 1.07)		1.02 (0.99, 1.05)		1.01 (0.97, 1.04)	
Hispanic	0.99 (0.97, 1.02)		0.97 (0.94, 0.99)**		0.998 (0.98, 1.02)		0.99 (0.97, 1.01)	

[a]All models include the following covariates: mother's age at first birth (categorical), concentrated poverty, residential stability, private insurance, connection with partner. Additional covariates vary by model, as noted below

[b]Covariates: all for the first child/pregnancy—diabetes, sex, adequate prenatal care, C-section delivery, birthweight, extremely premature (< 22 weeks)

[c]Covariates: all of the second child/pregnancy—sex of the child, diabetes, congenital anomalies, multiple births

[d]Covariates: for the first child/pregnancy—diabetes, sex of the child; for the second child/pregnancy—sex of the child, diabetes, congenital anomalies, multiple births

[e]Covariates: for the first child/pregnancy—diabetes, sex of the child, C-section delivery, preterm status; for the second child/pregnancy—sex of the child, diabetes, congenital anomalies

[f]Non-Hispanic

[g]Compared to propensity-score-matched group

*p < 0.05; **p < 0.01; ***p < 0.001

(5 classes per model). Program enrollment during the second pregnancy did not moderate the program effect for prenatal care, low birthweight, or preterm birth. Comparing NFN first and second children, we found no program effect when adjusting for trends between first and second control children.

Having a previous low birthweight child was associated with the likelihood of the second child having low birthweight (OR 3.71; 95% CI 2.70, 5.11), but there was no interaction between program enrollment and having a previous low birthweight child (p = 0.46). There was a significant interaction between a previous preterm child and the program effect for the likelihood of second child preterm status (p < 0.03; Fig. 2). Specifically, there was a protective program effect on prematurity of the second child (OR 0.92; 95% CI 0.85, 1.00) for women with a previous preterm birth (17.3% predicted probability of preterm second child for NFN women and 25.4% predicted probability for

comparison women), but not for women with a full-term first child (OR 1.01; 95% CI 0.99, 1.02).

Discussion

We examined whether participating in NFN with a first child benefits second children by improving pregnancy and birth outcomes. Overall, birth outcomes did not differ for second children born to NFN mothers compared to a demographically similar group. However, Black women in NFN were more likely to receive adequate prenatal care with their second pregnancy, and Hispanic women in NFN were less likely to deliver their second child by C-section. Additionally, among women who delivered preterm for their first birth, participation in NFN was associated with reduced risk of preterm birth for their second child, consistent with a previous finding for another home visiting program (Holland et al., 2018).

Table 4 Bivariate associations between group membership and outcomes, stratified by race and age categories

		PSM % (n)	NFN % (n)	p-value[a]
Adequate prenatal care (initiation by 5 months)				
Maternal race & ethnicity	White	93.2 (1280)	90.8 (374)	0.09
	Black	84.5 (899)	89.1 (352)	0.03*
	Hispanic	90.4 (2493)	89.6 (866)	0.43
Maternal age at first birth	12 to 15	88.9 (217)	87.9 (87)	0.78
	16 to 18	87.7 (1524)	88.4 (540)	0.68
	19 to 21	89.9 (1573)	89.0 (502)	0.55
	22 to 25	92.3 (754)	91.7 (255)	0.76
	26 to 34	94.7 (538)	93.3 (182)	0.84
Cesarean section				
Maternal race & ethnicity	White	31.2 (432)	6.7 (153)	0.04*
	Black	29.8 (322)	31.4 (127)	0.54
	Hispanic	28.2 (781)	27.5 (269)	0.70
Maternal age at first birth	12 to 15	23.5 (58)	15.0 (15)	0.08
	16 to 18	23.3 (408)	25.2 (156)	0.35
	19 to 21	28.7 (506)	29.5 (168)	0.70
	22 to 25	34.1 (280)	36.8 (104)	0.42
	26 to 34	36.7 (231)	46.7 (93)	0.08
Low birthweight				
Maternal race & ethnicity	White	4.9 (68)	6.0 (25)	0.38
	Black	8.1 (88)	10.2 (41)	0.22
	Hispanic	6.7 (186)	6.1 (60)	0.54
Maternal age at first birth	12 to 15	7.3 (18)	8.0 (8)	0.82
	16 to 18	6.7 (117)	8.1 (50)	0.25
	19 to 21	6.8 (119)	6.2 (35)	0.62
	22 to 25	6.0 (49)	6.4 (18)	0.81
	26 to 34	6.0 (35)	6.0 (12)	0.99
Preterm				
Maternal race & ethnicity	White	7.4 (103)	9.4 (39)	0.20
	Black	11.0 (119)	12.1 (49)	0.55
	Hispanic	9.5 (262)	8.4 (82)	0.32
Maternal age at first birth	12 to 15	13.4 (33)	12.0 (12)	0.73
	16 to 18	9.2 (160)	10.3 (64)	0.04
	19 to 21	9.0 (158)	8.3 (47)	0.61
	22 to 25	9.6 (79)	10.6 (30)	0.64
	26 to 34	7.8 (45)	6.6 (13)	0.59

[a] χ^2 test for equivalence between PSM comparison group and NFN second children

Black women face multiple barriers to accessing timely prenatal care, including perceived discrimination, structural racism, and other social determinants (e.g., insurance status, childcare and transportation availability) disproportionately harming people of color (Daniels et al., 2006; Gadson et al., 2017). Our results demonstrated that Black women who participated in HV had a higher probability of prenatal care before 5 months, similar to the full sample. This may be due to the actions of the community worker such as encouraging attendance and referrals to health and/or social service resources.

Participation in NFN was associated with reduced risk of C-section among Hispanic women, from a rate similar to the population average (9.1%) to 40% lower, which was the lowest predicted probability of any group. Although HV is unlikely to prevent emergency Cesarean deliveries, HV may reduce the incidence of planned C-sections by improving health literacy and encouraging open communication with healthcare providers. However, it is unclear why an effect was seen only among Hispanic women. It is possible that HV was particularly helpful for Spanish-speaking women, and connections with resources (e.g., translation services)

Fig. 1 Predicted probabilities for prenatal care and C-section by treatment group and race and ethnicity

Panel a. Prenatal care initiation by the fifth month of pregnancy.
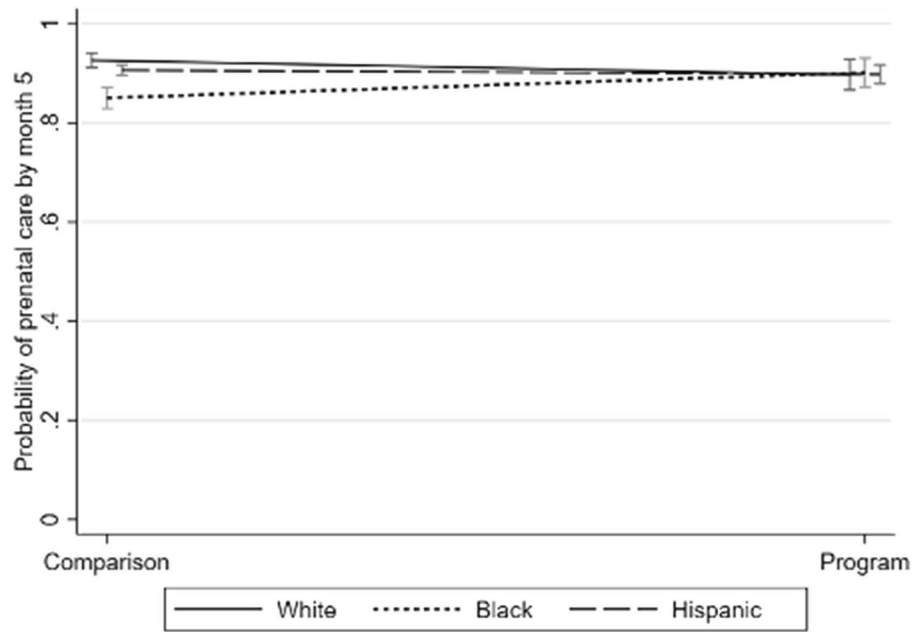
Panel b. Delivery by Cesarean section.
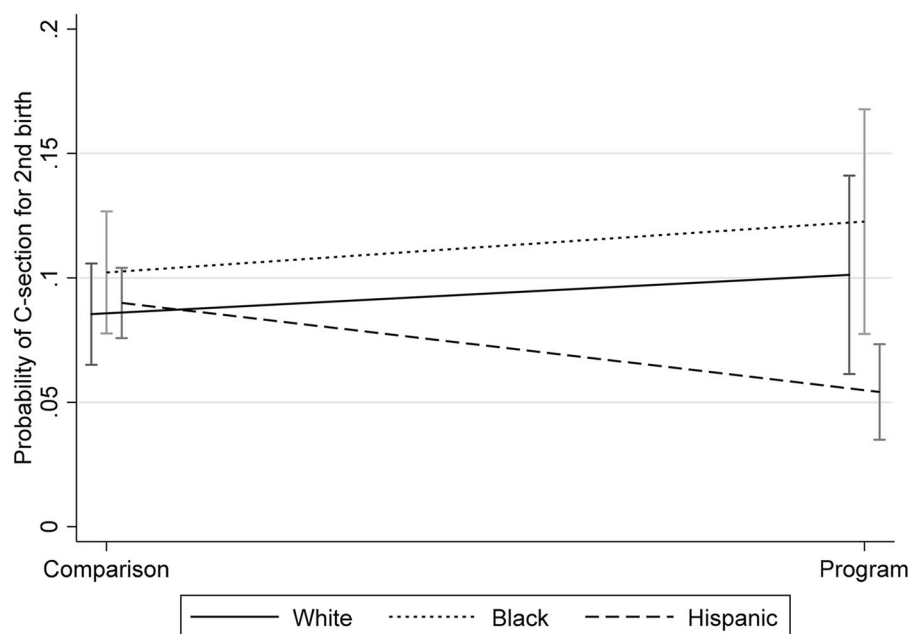
helped to empower women when planning for delivery. Approximately 20% of Hispanic women in our sample were born in a US territory (e.g., Puerto Rico) and 29% were born outside the US, suggesting English may not have been their first language. However, Hispanic ethnicity encompasses many cultures and backgrounds, and we did not have information on languages spoken or countries of origin to test this hypothesis.

HV did not appear to offset racial inequities in biological outcomes (low birthweight and preterm birth) which have been attributed to insidious factors like systemic racism and chronic stress (Gadson et al., 2017; Thoma et al., 2019). HV may be insufficient to offset racial inequities in biological outcomes, which are largely driven by insidious factors like systemic racism and chronic stress (Dominguez et al., 2008; Gadson et al., 2017). Other HV programs may be better suited to improve these outcomes (e.g., Nurse-Family
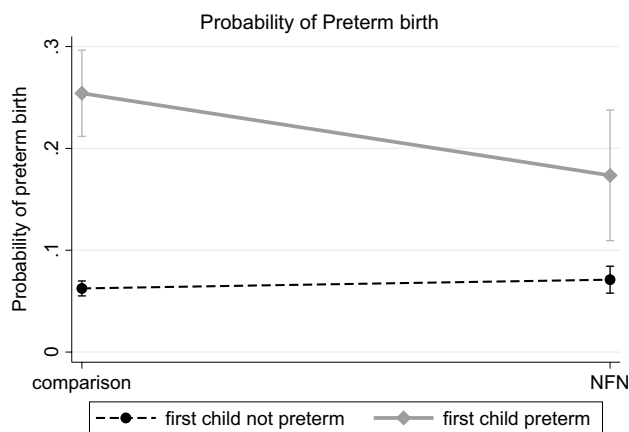
Fig. 2 Predicted probability of preterm birth by group (home-visited vs. propensity-score matched) and first child preterm status

Partnership employs healthcare professionals) and have demonstrated positive effects on preterm birth (e.g., Thorland & Currie, 2017). Identifying the specific program characteristics associated with improving birth outcomes is an important area for further study.

We did not find differences in outcomes based on maternal age or visit attendance patterns. This may be because we did not have information on other characteristics that may affect outcomes, such as family support or maternal mental health (Grigoriadis et al., 2013; Ramos et al., 2019), which could confound age and visit attendance associations. Furthermore, we did not have information about a family's level of engagement with the program or quality of the family-home visitor relationship. By excluding the youngest mothers due to small cell sizes, we may have missed program effects for this high-risk group of teenaged parents. Examining the influence of these factors is an important direction for future research.

In sensitivity analyses, we examined a second comparison group: first children of NFN families. We did not replicate the prenatal care initiation findings for Black women using this comparison group. One explanation is the small sample size; this secondary comparison group was about one-third as large as the PSM group and the effect size of the primary finding was small. We examined the possibility that families who enrolled in the program prenatally (approximately 20%) benefitted enough to reduce the difference between first and second pregnancies, but there was no evidence of a program effect on prenatal care for the first pregnancy (results not presented). It is possible that the PSM group and our secondary comparison group differed in unmeasured ways, which cannot be directly tested.

Strengths and Limitations

Use of a quasi-experimental design allowed for robust evaluation of NFN outcomes without conducting a resource-intensive randomized controlled trial. Sensitivity analyses were planned a priori and provided confirmation of our findings (Holland, 2019). While we did not detect meaningful differences between NFN and PSM groups, we cannot know if there were other important, but unmeasured, differences. Our study period ended in 2015 due to delayed availability of birth certificate data. The home visiting program has since changed, with an expanded mental health component. However, most participants are still first-time mothers and there is no specific focus on subsequent birth outcomes. Our large sample size allowed us to examine moderating effects, although some subgroups were too small for analysis. Even though the primary goal of NFN is to promote positive parenting and reduce child maltreatment (Joslyn et al., 2016), our findings regarding impact on second children suggests that NFN may have beneficial impact on health outcomes (e.g., lower C-section risk for Hispanic women, and trend toward lower preterm births). Healthcare system changes during the study period may have influenced our findings, such as the introduction of the Affordable Care Act ("Patient Protection and Affordable Care Act of 2010", 2010) improving healthcare access or increasing use of long-acting reversible contraception reducing second births (Finer et al., 2012), but these would impact both NFN and comparison groups similarly; it is notable that the C-section rate was stable over this period in Connecticut (Issel et al., 2015). Using administrative data did not allow analyses to include important factors, such as mental health, stress, and trauma; future research should consider these as potential mechanisms through which home visiting may improve birth outcomes. Data were from a single state; future research should seek to replicate our findings.

Conclusion

Our findings offer promising evidence that NFN may extend some benefits to second children of home-visited families, particularly those at high risk for health inequities and with risks based on previous outcomes such as prematurity. These findings provide support to the existing literature to justify funding these programs as well as the program's practice of targeting first-time parents. They also support the need for future work to investigate second child HV outcomes.

Declarations

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