



Effects of a Multi-site Expansion of Group Prenatal Care on Birth Outcomes

Amy H. Crockett¹ · Emily C. Heberlein² · Jessica C. Smith² · Pelin Ozluk³ · Sarah Covington-Kolb⁴ · Carla Willis²

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Abstract

Objectives Perinatal Quality Collaboratives across the United States are initiating projects to improve health and healthcare for women and infants. We compared an evidence-based group prenatal care model to usual individual prenatal care on birth outcomes in a multi-site expansion of group prenatal care supported by a state-wide multidisciplinary Perinatal Quality Collaborative. **Methods** We analyzed 15,330 pregnant women aged 14–48 across 13 healthcare practices in South Carolina (2013–2017) using a preferential-within cluster matching propensity score method and logistic regression. Outcomes were extracted from birth certificate data. We compared outcomes for (a) women at the intent-to-treat level and (b) for women participating in at least five group prenatal care visits to women with less than five group visits with at least five prenatal visits total. **Results** In the intent-to-treat analyses, women who received group prenatal care were significantly less likely to have preterm births (absolute risk difference – 3.2%, 95% CI – 5.3 to – 1.0%), low birth weight births (absolute risk difference – 3.7%, 95% CI – 5.5 to – 1.8%) and NICU admissions (absolute risk difference – 4.0%, 95% CI – 5.6 to – 2.3%). In the as-treated analyses, women had greater improvements compared to intent-to-treat analyses in preterm birth and low birth weight outcomes. **Conclusions for Practice** CenteringPregnancy group prenatal care is effective across a range of real-world clinical practices for decreasing the risk of preterm birth and low birth weight. This is a feasible approach for other Perinatal Quality Collaboratives to attempt in their ongoing efforts at improving maternal and infant health outcomes.

Keywords Birth outcomes · CenteringPregnancy · Group prenatal care · Low birthweight · Preterm birth

Significance

This study compares the effects of a multi-site expansion of an evidence-based group prenatal care model to individual prenatal care on birth outcomes in a large, racially diverse

sample of women across 13 clinical practices. This paper applies novel propensity score methods to reflect the nested practice data structure and examines outcomes at both the intent-to-treat and as-treated level in order to reflect real-world clinical implementation. This study provides evidence, building on controlled trials with homogeneous samples, that group prenatal care expansion can be a feasible approach for Perinatal Quality Collaboratives to implement to improve birth outcomes.

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✉ Emily C. Heberlein
eheberlein@gsu.edu

¹ Prisma Health Upstate, University of South Carolina School of Medicine Greenville, Greenville, SC, USA

² Georgia Health Policy Center, Andrew Young School of Policy Studies, Georgia State University, Atlanta, GA, USA

³ Department of Economics, Andrew Young School of Policy Studies, Georgia State University, Atlanta, GA, USA

⁴ Prisma Health Upstate, Greenville, SC, USA

Introduction

In the last decade, as part of efforts to improve the health and healthcare of mothers and infants, more than 40 states have developed multidisciplinary perinatal quality collaboratives (PQCs) (Gupta et al. 2017; Schneider et al. 2017). These groups are supported by national public health agencies, including the Centers for Disease Control and Prevention and the American College of Obstetrics and Gynecology.

Initiatives promoted for implementation by PQCs are based in quality improvement science, and often organized into “bundles” that include clinical guidelines, engagement of diverse practice- and hospital-level sites, and rigorous data collection designed to measure improvements in health outcomes. The Alliance for Innovation on Maternal Health (AIM) initiative, for example, provides guidance for “bundles” reducing maternal hemorrhage and severe hypertension/pre-eclampsia (American College of Obstetricians & Gynecologists, n.d., Centers for Disease Control and Prevention 2018). PQCs have also collaborated to address early elective deliveries and blood stream infections among pre-term babies (Henderson et al. 2014).

The South Carolina PQC, the Birth Outcomes Initiative, was founded in 2011 to address the state’s rates of poor birth outcomes (South Carolina Department of Health and Human Services 2016). The PQC has supported several initiatives, including reducing early elective deliveries, increasing access to long-acting reversible contraceptives, increasing the number of Baby-Friendly hospitals, and expanding access to the CenteringPregnancy™ model of group prenatal care (GPNC). CenteringPregnancy was selected because of (1) the evidence of improved birth outcomes and its potential to decrease racial disparities (Ickovics et al. 2007) and (2) the provider training and site certification infrastructure available from the Centering Healthcare Institute (Boston, MA) to ensure practices provide GPNC with fidelity to the CenteringPregnancy model.

While evidence for GPNC is promising, the number of CenteringPregnancy studies is relatively small and largely observational. Several studies including one randomized controlled trial demonstrated improved perinatal outcomes, including a 33% reduced risk for preterm birth with greater effects among black women (Crockett et al. 2017; Cunningham et al. 2018; Gareau et al. 2016; Ickovics et al. 2016; Ickovics et al. 2007; Picklesimer et al. 2012). A cluster randomized controlled trial among adolescents in New York City health centers found no effects in intent-to-treat analyses on gestational age and birthweight, although women with more group visits had improvements in these outcomes in as-treated analyses (Ickovics et al. 2016). A recent meta-analysis found no significant differences in perinatal outcomes but did not analyze differential outcomes by race (Carter et al. 2016). The Strong Start for Mothers and Newborns initiative, supported by the Centers for Medicare and Medicaid Innovation (2013–2017), included 15 awardees at 60 sites implementing group prenatal care practices. Results comparing group prenatal care-enrolled women to a propensity-score weighted comparison group not receiving group care did not find differences in preterm birth or low birthweight (Urban Institute 2018). A five-site evaluation study in Tennessee documented longer weeks of gestation and higher birth weight, but no difference in odds of preterm

birth or low birthweight for CenteringPregnancy (Tanner-Smith et al. 2014). Across studies, dose response analyses and selection criteria vary in their rigor and additional study is warranted to clarify outcomes, particularly in a range of practice settings.

The CenteringPregnancy expansion was funded by the South Carolina Department of Health and Human Services (SC DHHS) and the South Carolina Chapter of the March of Dimes and coordinated through the Department of Obstetrics and Gynecology at Greenville Health System (now Prisma Health Upstate), one of the three academic medical centers in the state.

The initiative provided training, technical assistance, and start-up funds to obstetric practices selected through a competitive application process. SC DHHS also created a new CPT code to provide enhanced reimbursement for women seen in GPNC visits. Enhanced reimbursement was believed to be critical for long-term sustainability and helped offset the cost of reduced provider productivity and the cost of supplies for group educational activities. The CenteringPregnancy expansion initiative began in 2012, and by the summer of 2018, 24 practices from across the state were participating.

This retrospective cohort study represents the program evaluation of this initiative. In this evaluation, we aim to address the following research questions: Do women participating in CenteringPregnancy across multiple practices implementing high-fidelity group services have improved birth outcomes to a comparable group of women receiving individual prenatal care, and how do outcomes differ by race? Do women attending a minimum number of visits experience better outcomes in CenteringPregnancy? The primary outcomes for this evaluation are preterm birth (prior to 37 weeks gestational age), low birthweight (<2500 g), and neonatal intensive care unit (NICU) admissions.

Materials and Methods

Prenatal Care Models

In CenteringPregnancy, prenatal care is provided in ten 120 min group sessions with six to twelve pregnant women that have due dates in the same 4–6 week range. During the first 30 min of each group session, medical care providers perform an individual routine medical assessment. In the remaining 90 min, women participate in facilitated group discussions and activities led by the medical care team that follow a curriculum focused on issues related to pregnancy, childbirth, and parenting. With limited time for medical assessment and an emphasis on women building group cohesion, many practices restrict CenteringPregnancy eligibility

to women with low risk pregnancies who begin prenatal care before 20 weeks' gestation (Rising et al. 2004).

The American College of Obstetrics and Gynecology's practice guidelines for individual care include an examination and testing schedule, anticipatory guidance, and health education for individual prenatal care. CenteringPregnancy follows the same schedule and provides expanded opportunity for the education and support components of prenatal care, allowing women to increase their social support, change norms on health behaviors, and share information with one another, potentially reducing stress, changing behavior, and improving birth outcomes (Rising et al. 2004),

Study Population and Data Sources

In this expansion project, each practice was allowed to develop its own eligibility criteria and recruitment strategies for group prenatal care and these were all consistent with Centering Healthcare Institute recommendations. All participating practices offered both group and individual care models, and women were allowed to choose the model of care they preferred. Practices submitted lists of women participating in GPNC biannually (including name, social security number, date of birth, baby's date of birth, and number of GPNC sessions attended) to the expansion's technical assistance provider who reviewed and collated for the South Carolina Revenue and Fiscal Affairs (RFA) Office. RFA used a standardized algorithm to match the list to birth certificate data (standard United States birth certificate, 2003 version) using personal identifiers provided, accounting for misspelling, name changes, and transposed digits, with a resulting match score calculated; scores below a specific threshold were discarded as non-matches. RFA then identified a comparison group of deliveries, matched by National Provider Identifier (NPI) of the delivering provider, delivery month, and year. The de-identified birth certificate variables included maternal demographics, maternal pregnancy and health characteristics, newborn characteristics, timing of entry to prenatal care, number of prenatal care visits, provider, year of birth, and birth complications and outcomes.

While 24 practices have participated in the initiative, 11 are too early in the implementation process to have vital statistics data available on babies delivered. We use data from 13 practices where at least one CenteringPregnancy group has had all women deliver babies and vital statistics birth certificate data has been processed. Two practices are located within academic obstetrics and gynecology departments, two are academic family medicine practices, and the remainder are private obstetrics and gynecology practices. Two sites had been providing CenteringPregnancy since 2008; five sites joined the expansion effort in 2013, two sites in 2014, three sites in 2015, and one site in 2016. All sites participated in the technical assistance and enhanced

reimbursement offered by the expansion project. Twelve sites had received site certification from the Centering Healthcare Institute in 2016 or earlier, and one site was in the process of applying for site certification during the study period (receiving certification in 2018). Births occurred between 2013 and early 2017. In order to maintain independence, only the first birth during the time period was included for women with more than one pregnancy. Women with multiple gestation were excluded. Women were not excluded for high-risk medical conditions indicated on birth certificates or for late entry to care.

This research was approved by the institutional review board at Prisma Health which did not require informed consent for the use of preexisting administrative data. The second and third authors, who had full access to all study data, assume responsibility for the data analysis.

Treatment Levels

Providers compiled visit counts for GPNC which were subtracted from prenatal care visits reported on birth certificates to create variables for each woman for each model of care. To reflect women's varied use of prenatal care in real-world clinical settings, we defined two levels of prenatal care use a priori. The intent-to-treat level compared women with one or more GPNC visits to women receiving individual prenatal care with no GPNC visits. The as-treated level compared women with five or more GPNC visits to women with less than five GPNC visits with at least five prenatal visits total (Crockett et al. 2017; Cunningham et al. 2017; Ickovics et al. 2016).

Statistical Analysis

Propensity Score Matching

Because randomizing women to GPNC or individual care was not possible in this statewide initiative, we developed propensity scores to reduce observable differences (e.g. that may indicate selection bias) and permit more rigorous comparisons between groups. This technique helps to ensure that differences between groups are because of the treatment they received as opposed to other reasons (Crockett et al. 2017; Hale et al. 2014; Rosenbaum and Rubin 1983, 1985; Rubin 2007). We assessed the potential of all variables in our dataset to contribute to the propensity score estimation. Following the methods employed by Tanner-Smith et al. in their evaluation of CenteringPregnancy practices in Tennessee, we identified matching variables by performing a bivariate correlation analysis with each potential predictor variable versus the treatment variable (GPNC) and each outcome of interest. If the correlation between a predictor and treatment or any outcome was

greater than |0.10| and the literature supported its inclusion, then we included the predictor as a matching variable (Tanner-Smith et al. 2012). This approach was selected to balance concerns about omitting important covariates from the propensity score estimation, which may result in biased estimates, against including too many inconsequential variables that may increase estimate variance (Bryson et al. 2002; Heckman et al. 1998; Tanner-Smith et al. 2012). Variables included in the propensity scores were: month care began, parity, previous preterm birth, women's race, women's age, previous cesarean, body mass index (BMI) and insurance coverage. The Kotelchuck Index, an indicator of the adequacy of prenatal care use, was not included because of multicollinearity with the 'month prenatal care began' variable. We addressed number of prenatal care visits through our analysis of two levels of treatment. Variables tested but not meeting the criteria of the aforementioned correlation threshold were women's education, women's county, WIC enrollment, pre-pregnancy diabetes, pre-pregnancy hypertension, smoked during pregnancy, and smoked before pregnancy. The sub-analysis by race excluded maternal race as a matching variable (Tanner-Smith et al. 2012; Tanner-Smith et al. 2014). The propensity score is the predicted probability of participating in GPNC considering values for each of these variables.

We then performed a preferential-within cluster matching process, matching women in GPNC to women in individual care with similar propensity scores within each practice site. If a within-site match was not identified, the algorithm matched to an individual care patient at a different site. This technique accounts for the nested nature of the data where women received prenatal care at 13 practices with different contexts and widely varying sample sizes (Arpino and Cannas 2016). The preferential-within matching technique developed by Arpino and Cannas (2016) performs well among a mix of cluster sizes by reducing the number of unmatched cases we may experience matching only within clusters while also improving the balance of covariates and potential confounders relative to a pooled matching approach. Arpino and Cannas also demonstrated that the preferential-within matching approach performs better than fixed and random effects techniques when matching with replacement (as we did in this study). To confirm that the propensity score matching technique resulted in balanced groups, we compared the balance of the variables used to develop the propensity scores between GPNC and individual care before and after matching. To address concerns about the potential effects of omitted confounders, we also tested our propensity score matching analysis using fixed effects and random effects approaches; the results of these tests were largely consistent.

Outcomes

The impact of GPNC on each outcome was evaluated using simple logistic regression models with the matched GPNC and individual care cohorts. Each analysis was repeated for intent-to-treat and as-treated levels. We repeated the analysis for black women to assess the impact on racial disparities in outcomes, one of the primary goals of the initiative. In this analysis, race was excluded from the propensity scores and used as a variable to stratify the analysis. Lastly, we examined whether the impact of GPNC was significantly different across black women and non-black women. Because of surveillance data indicating racial disparities are between black and other racial groups, white, Hispanic, and other races were combined in analyses.

Results

Population Characteristics

GPNC practices vary in total size, volume of groups, and the proportion of women with Medicaid coverage for their delivery (Table 1). Practice rates of Medicaid enrollment ranged from 80 to 94% (mean 90%) and 33–91% (mean 60%) for individual care and GPNC respectively. Practices are located in all regions within the state.

The South Carolina Revenue and Fiscal Affairs Office matched 86% of 4206 women on provider-reported GPNC lists to birth certificates (range of 75–92% by practice) and identified 12,795 women in individual care with no GPNC visits who delivered with the same providers. After exclusions, we included 3460 women in GPNC and 11,870 women in individual care (Fig. 1). GPNC and individual care participants differed across demographic characteristics, prenatal care access, and risk factors for poor birth outcomes (Table 2). The propensity-matching procedures met accepted thresholds for balancing groups prior to outcomes analysis (Supplemental Table S1).

Outcomes

GPNC was significantly associated with decreased odds of preterm birth, low birthweight, and NICU admissions at the intent-to-treat (ITT) level, our primary level of analysis (Table 3). ITT analyses show that GPNC was significantly associated with decreased risk of preterm birth (10.6% risk in individual care and 7.5% risk in GPNC); decreased risk of low birthweight (10.7% risk in individual care and 7.0% risk in GPNC); and decreased risk in NICU admissions (10.1% risk in individual care and 6.2% risk in GPNC). In the as-treated level, the impact of GPNC was relatively greater but comparable in preterm birth and low birthweight outcomes.

Table 1 Practice size, type, and Medicaid enrollment across CenteringPregnancy GPNC practices (January 2013–May 2017)

Practice type	Number of women			Percent enrolled in Medicaid		
	Individual care	CenteringPreg-nancy GPNC	Total	Individual care (%)	CenteringPregnancy GPNC (%)	Total (%)
Academic OB-GYN service	3578	1455	5033	91	82	89
Academic OB-GYN service	2120	241	2361	92	82	91
Private OB-GYN	1514	204	1718	95	33	87
Private OB-GYN	1356	261	1617	84	50	78
Private OB-GYN	697	488	1185	80	47	67
Private OB-GYN	752	120	872	87	47	82
Private OB-GYN	696	137	833	93	85	92
Private OB-GYN	351	97	448	94	68	89
Academic family medicine	229	123	352	93	90	92
Private OB-GYN	228	95	323	92	65	84
Private OB-GYN	133	60	193	92	78	88
Private OB-GYN	104	80	184	86	19	57
Academic family medicine	71	95	166	86	35	57
Total	11,829	3456	15,285	90	67	85

This table includes births for all years each practice provided CenteringPregnancy GPNC

We also investigated whether there are differential effects of GPNC by race (Table 4). GPNC compared to individual care is associated with significant improvement in low birthweight among black women at both ITT and as-treated levels (13.5% risk vs. 9.5% risk at ITT level). GPNC is also associated with significant decreases in preterm births and NICU admissions versus individual care at the as-treated level among black women (6.2% risk vs. 10.5% risk for preterm births; 6.3% risk vs. 10.8% risk for NICU admissions). Among non-black women GPNC is associated with significant decreases in low birthweight birth and NICU admissions at both levels, and significant decreases in preterm births at the as-treated level. The results do not indicate that the impact of GPNC was statistically different between black and non-black women except for NICU admissions in the intent-to-treat analysis, where non-black women exhibited a statistically significant but clinically modest greater improvement [non-black individual care 8.9% risk vs. GPNC 5.2% risk, black individual care 8.8% risk vs. GPNC 7.8% risk (Supplemental Tables S2 and S3)].

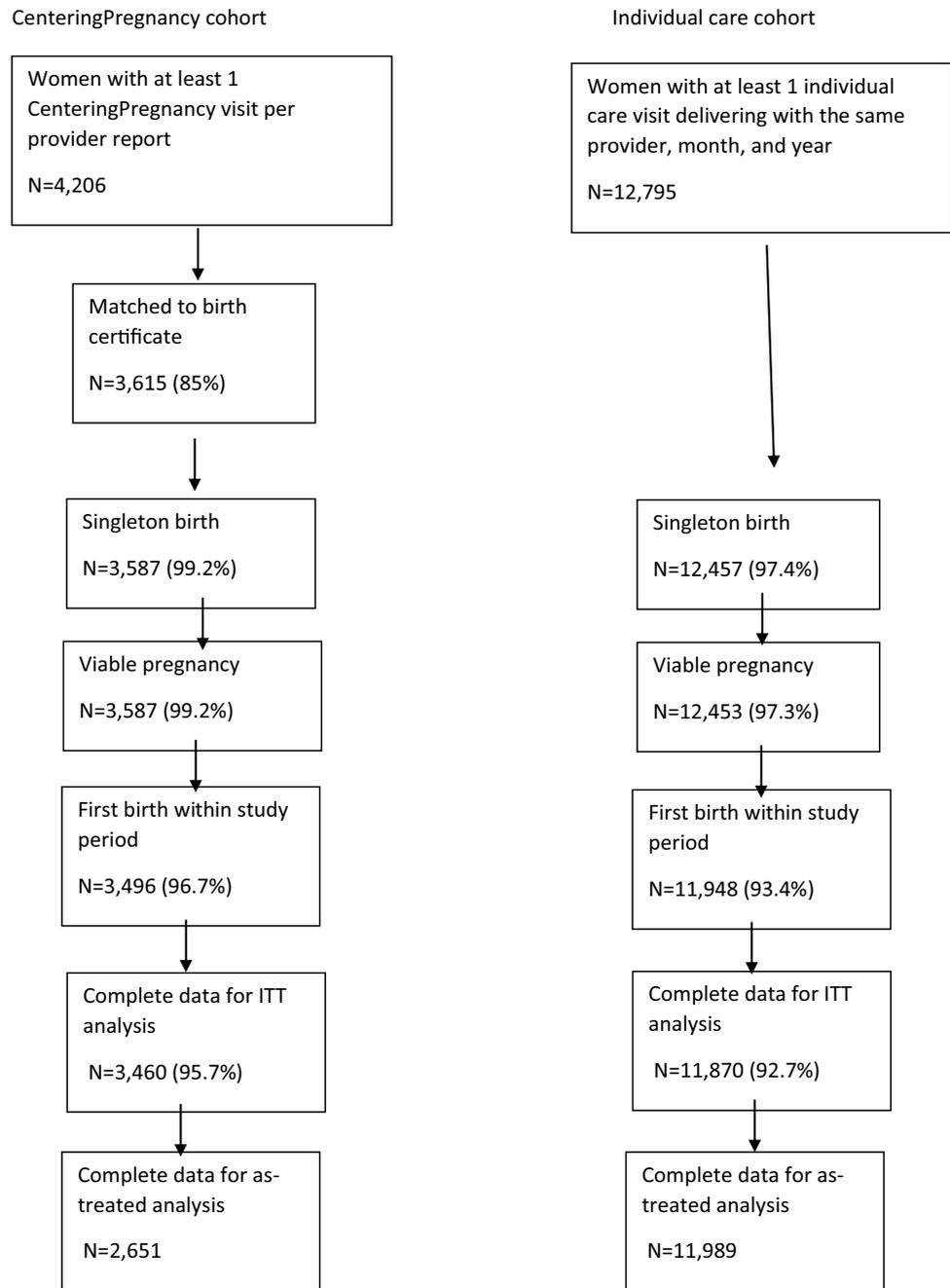
Conclusions for Practice

This propensity-score matched retrospective cohort study demonstrated the effectiveness of CenteringPregnancy GPNC across a range of real-world clinical practices for decreasing the risk of preterm birth and low birthweight. This paper represents the first publication of a wide-scale attempt at implementation of GPNC, and the results from this evaluation indicate that this is a feasible approach for

other Perinatal Quality Collaboratives to attempt in their ongoing efforts at improving maternal and infant health outcomes. Our effect sizes in intent-to-treat analyses were -3.2% , -3.7% and -4.0% in absolute risk differences for preterm birth, low birthweight birth and NICU admissions respectively. Our results are consistent with one randomized control trial of GPNC and two retrospective cohort studies (Cunningham, et al. 2018; Ickovics et al. 2007; Picklesimer et al. 2012). By comparison, the Strong Start Initiative evaluation did not demonstrate better outcomes for GPNC. Sites were not required to follow a specific model or curriculum, some sites targeted different sub-populations (i.e. based on risk factors), and the impact evaluation design was limited to sites with opt-in participation rates exceeding 75% (Urban Institute 2018). Our sub-analyses limited to black women indicate black women experience lower rates of low birthweight in ITT and as-treated analyses, and lower rates of preterm birth and NICU admissions in as-treated analyses. We did not replicate the finding that GPNC has a *greater* positive effect on preterm birth or low birthweight among black women compared to non-black women. This suggests that this model of group prenatal care does not worsen persistent racial disparities but benefits racial groups similarly after they are matched on other variables including insurance coverage and timing of entry to care.

In our real-world implementation study including a large and racially diverse sample, a higher proportion of individual care participants were covered by Medicaid and entered care later in their pregnancy. While these factors were balanced through propensity scores, this descriptive data suggests continued need to address system-level barriers to

Fig. 1 CenteringPregnancy GPNC and individual care cohorts



accessing care. While the rate of late entry to care is not a novel finding, late entry to care will often limit opportunities to participate in GPNC, as best practices for Centering-Pregnancy GPNC indicate women should join GPNC before 20–24 weeks’ gestation.

This paper has several limitations. Because not all factors which influence women’s choice of prenatal care model are available in the data, the propensity scores do not fully account for self-selection bias. These factors include levels of engagement in healthy behaviors and healthcare, and social factors operating as barriers

or facilitators to attending GPNC (including transportation, employment flexibility, unstable housing, and parenting responsibilities), which also may influence birth outcomes. Our approach to address selection bias using the data available in this retrospective study is consistent with the approach used in other studies (Tanner-Smith et al. 2012). While the effects of GPNC are stronger among the as-treated group, women with very premature births may not have had an opportunity to attend five prenatal visits and would thus be excluded from this treatment level. The analysis does match on a broad range of factors

Table 2 Characteristics and outcomes (before propensity score matching) of Women in CenteringPregnancy GPNC and individual care, 2013–2017

Characteristics	Intent-to-treat (ITT)		Individual care (N=11,870)		Centering Preg-nancy GPNC (N= 3460)		Total (N= 15,330)	P value
	No.	%	No.	%	No.	%		
Maternal age category								0.01
< 18	365	3.1	137	4.0	502	3.3		
18–25	6048	51.0	1746	50.5	7794	50.8		
26–35	4707	39.7	1392	40.2	6099	39.8		
> 35	750	6.3	185	5.3	935	6.1		
Maternal race								<0.01
Black	5688	47.9	1309	37.8	6997	45.6		
White	5406	45.5	1636	47.3	7042	45.9		
Hispanic	645	5.4	480	13.9	1125	7.3		
Other	131	1.1	35	1.0	166	1.1		
# Previous live births								<0.01
0	4305	36.3	1987	57.4	6292	41.0		
1	3574	30.1	834	24.1	4408	28.8		
2 +	3991	33.6	639	18.5	4630	30.2		
Month PNC began								
0–2 months	4100	34.5	1533	44.3	5633	36.7		
3–4 months	4979	41.9	1707	49.3	6686	43.6		
5 + months	2791	23.5	220	6.4	3011	19.6		
Payer								<0.01
Medicaid	10,701	90.4	2335	67.5	13,036	85.2		
Other	25	0.2	135	3.9	160	1.0		
Private Ins.	1045	8.8	838	24.2	1883	12.3		
Self-pay	65	0.5	150	4.3	215	1.4		
BMI > 45								<0.01
No	11,231	94.6	3389	97.9	14,620	95.4		
Yes	639	5.4	71	2.1	710	4.6		
Previous cesarean								<0.01
0	9648	81.3	3115	90.0	12,763	83.3		
1	2222	18.7	345	10.0	2567	16.7		
Previous preterm birth								<0.01
No	10,924	92.0	3346	96.7	14,270	93.1		
Yes	946	8.0	114	3.3	1060	6.9		
Outcomes								
Cesarean delivery								<0.01
No	8226	69.3	2588	74.8	10,814	70.5		
Yes	3644	30.7	872	25.2	4516	29.5		
Preterm birth								<0.01
No	10,609	89.4	3200	92.5	13,809	90.1		
Yes	1261	10.6	260	7.5	1521	9.9		
Low birthweight								<0.01
No	10,699	90.1	3218	93.0	13,917	90.8		
Yes	1171	9.9	242	7.0	1413	9.2		
NICU admission								<0.01
No	10,760	90.6	3245	93.8	14,005	91.4		
Yes	1110	9.4	215	6.2	1325	8.6		

Table 3 Adjusted odds ratios, absolute differences in risk and risks according to CenteringPregnancy group prenatal care (GPNC) and individual care

Outcomes and treatment level	Adjusted odds ratio individual care vs. GPNC (95% CI)	P-value	Absolute difference in risk, individual care vs. GPNC (%) (95% CI)	P-value	Risk individual care (%) (95% CI)	Risk GPNC (%) (95% CI)
Preterm birth						
Intent-to-treat	0.681 (0.627 to 0.741)	0.001	- 0.032 (- 0.053 to - 0.010)	0.004	0.106 (0.101 to 0.112)	0.075 (0.071 to 0.080)
As-treated	0.595 (0.536 to 0.660)	<0.001	- 0.036 (- 0.057 to - 0.014)	0.001	0.092 (0.087 to 0.097)	0.057 (0.053 to 0.061)
Low birthweight						
Intent-to-treat	0.635 (0.583 to 0.691)	<0.001	- 0.037 (- 0.055 to - 0.018)	<0.001	0.107 (0.102 to 0.112)	0.070 (0.066 to 0.075)
As-treated	0.549 (0.493 to 0.612)	<0.001	- 0.039 (- 0.058 to - 0.020)	<0.001	0.090 (0.085 to 0.095)	0.051 (0.047 to 0.056)
NICU admission						
Intent-to-treat	0.587 (0.537 to 0.642)	<0.001	- 0.040 (- 0.056 to - 0.023)	<0.001	0.101 (0.096 to 0.106)	0.062 (0.058 to 0.066)
As-treated	0.594 (0.532 to 0.663)	<0.001	- 0.032 (- 0.050 to - 0.014)	<0.001	0.082 (0.077 to 0.087)	0.050 (0.046 to 0.055)

Table 4 Risks and absolute differences in risks, individual care and CenteringPregnancy group prenatal care, by race

Outcomes	Race and treatment level	Absolute difference in risk, individual care vs. GPNC (%)			Risk individual care (%)		Risk GPNC (%)	
		Estimate	(95% CI)	P-value	Estimate	(95% CI)	Estimate	(95% CI)
Preterm birth								
	Non-black							
	Intent-to-treat	- 0.030	(- .062 to .002)	0.069	0.099	(.064 to .149)	0.069	(.058 to .082)
	As-treated	- 0.038	(- .073 to - .002)	0.036	0.091	(.062 to .133)	0.053	(.043 to .065)
	Black							
	Intent-to-treat	- 0.017	(- .049 to .015)	0.293	0.102	(.074 to .139)	0.085	(.064 to .110)
	As-treated	- 0.043	(- .065 to - .020)	<0.001	0.105	(.082 to .133)	0.062	(.053 to .072)
Low birth weight								
	Non-black							
	Intent-to-treat	- 0.030	(- .056 to - .003)	0.027	0.084	(.063 to .111)	0.054	(.038 to .076)
	As-treated	- 0.034	(- .048 to - .019)	<0.01	0.074	(.055 to .097)	0.040	(.027 to .059)
	Black							
	Intent-to-treat	- 0.040	(- .064 to - .016)	0.001	0.135	(.104 to .173)	0.095	(.079 to .113)
	As-treated	- 0.070	(- .108 to - .032)	<0.001	0.140	(.109 to .179)	0.070	(.062 to .080)
NICU admission								
	Non-black							
	Intent-to-treat	- 0.037	(- .057 to - .018)	<0.001	0.089	(.063 to .125)	0.052	(.036 to .074)
	As-treated	- 0.043	(- .071 to - .015)	0.003	0.086	(.052 to .139)	0.043	(.031 to .061)
	Black							
	Intent-to-treat	- 0.009	(- .034 to .015)	0.461	0.088	(.057 to .132)	0.078	(.063 to .097)
	As-treated	- 0.045	(- .067 to - .022)	<0.001	0.108	(.077 to .148)	0.063	(.047 to .083)

and accounts for the nesting of women within practices in comparison to other published studies.

While all practices participated in the same training and technical assistance and were certified (or in the process of becoming certified) CenteringPregnancy sites through the Centering Healthcare Institute, we did not further assess implementation fidelity for this study. Additional research

of implementation strengths and challenges at the practice level and how these influence outcomes may provide more specific recommendations for technical assistance, alternative payment models, and policy support.

Because of the range of insurance payers, we are not able to incorporate healthcare costs into this analysis. Including women with a range of insurance types is a valuable proxy

for income status and reflects real-world practice in our sites where eligibility for CenteringPregnancy is not dependent on type of insurance. Additional research on cost implications for practice implementation, scale up efforts, and cost effectiveness compared to other clinical interventions is needed. While studies of other clinical interventions to prevent preterm birth, including vaginal progesterone for ultrasonographically short cervix and 17 alpha hydroxyprogesterone caproate for women with a history of previous preterm birth, demonstrate greater effect sizes for prevention of recurrent preterm birth, these interventions can be costly and pose challenges for patient access and adherence (Hassan et al. 2011; Meis et al. 2003).

This initiative is part of a national effort to meaningfully engage individual practices with high-quality, high-fidelity practice improvement initiatives. It was able to engage a large number of practices and healthcare providers. Nearly 400 physicians, nurses, nurse practitioners, certified nurse midwives, certified medical assistants, and office administrators have participated in GPNC training sessions over the course of the initiative. Despite this reach, the initiative was still only able to provide GPNC to a minority of pregnant women. The births in the dataset (combining both individual and GPNC) represent approximately 6% of South Carolina births and 11% of Medicaid-covered births between 2013 and 2016 in total. CenteringPregnancy participants reflect about 1.3% of deliveries and 1.7% of Medicaid-covered deliveries over the years 2013–2016 (South Carolina Community Access Network 2016).

The findings from this state-wide GPNC expansion suggest that policies supporting increased reach and retention in GPNC may contribute to greater positive birth outcomes. The initiative's progress should encourage other states considering ambitious quality improvement efforts; this initiative was well-received by healthcare providers in diverse practice environments and the results indicate progress toward the shared goals of improved pregnancy outcomes.

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Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflict of interest.

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