

OBSTETRICS

Quantifying the association between doula care and maternal and neonatal outcomes



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BACKGROUND: The United States suffers from an increasing rate of severe maternal morbidity, paired with a wide disparity in maternal health by race. Doulas are posited to be a useful resource to increase positive outcomes and to decrease this disparity.

OBJECTIVE: This study aimed to evaluate the association between doula care and a broad range of maternal and neonatal outcomes in various subpopulations.

STUDY DESIGN: This was a retrospective cohort study of deliveries that were recorded from January 2021 to December 2022 at a single institution where they received prenatal care. The exposure was receipt of doula care prenatally and at delivery. We evaluated both the maternal (cesarean delivery, cesarean delivery of nulliparous, term, singleton, vertex infant, vaginal birth after cesarean, gestational hypertension, pre-eclampsia, postpartum emergency department visit, readmission, and attendance of postpartum office visit) and neonatal (neonatal intensive care unit admission, unexpected complications in term newborns, breastfeeding, preterm delivery, and intrauterine growth restriction) outcomes. Because our institution previously employed targeted outreach by offering doula services to patients at highest risk, we used multiple methods to generate an appropriate comparison population. We conducted a multivariate logistic regression and conditional regressions using propensity scores to model the likelihood of doula care to generate adjusted risk differences associated with doula care. Analyses were repeated in populations stratified by race (White vs Black) and then by payor status (public vs commercial).

RESULTS: Our cohort included 17,831 deliveries; 486 of those received doula care and 17,345 did not. Patients who received doula care were more likely to self-report Black race, be publicly insured, and to live in a more disadvantaged neighborhood. Regardless of the analytical approach, for every 100 patients who received doula care, there were 15 to 34 more vaginal births after cesarean (adjusted risk difference, 15.6; 95% confidence interval, 3.8–27.4; adjusted risk difference, 34.2; 95% confidence interval, 0.046–68.0) and 5 to 6 more patients who attended a postpartum office visit (adjusted risk difference, 5.4; 95% confidence interval, 1.4–9.5; adjusted risk difference, 6.8; 95% confidence interval, 3.7–9.9) when compared with those who did not receive doula services. Infants born to these patients were 20% more likely to be exclusively breastfed (adjusted risk ratio, 1.22; 95% confidence interval, 1.07–1.38), and doula care was associated with 3 to 4 fewer preterm births (adjusted risk difference, –3.8; 95% confidence interval, –6.1 to –1.5; –4.0; 95% confidence interval, –6.2 to –1.8) for every 100 deliveries that received doula care. Results were consistent regardless of race or insurance. Results were also consistent when doula care was redefined as having at least 3 prenatal encounters with a doula.

CONCLUSION: Doula care was associated with more vaginal births after cesarean delivery, improved attendance of postpartum office visits, improved breastfeeding rates, and fewer preterm deliveries. The effect of doula care was consistent across race and insurance status.

Key words: breastfeeding, doula, postpartum utilization, preterm birth, race, vaginal birth after cesarean (VBAC)

Introduction

Maternal morbidity and mortality are increasing at alarming rates in the United States and the racial disparity continues to widen.¹ In 2021, Black persons in the United States were 2.6 times more likely to experience maternal death than White persons.^{2,3} Similar to maternal out-

comes, infants born to non-Hispanic Black persons had twice the rate of infant mortality than their non-Hispanic White counterparts in 2019 in the United States.⁴ One approach that was adopted more recently to help address poor outcomes with the hopes of also decreasing racial disparities is the use of doula support.^{5–7}

It has been suggested that doula care may have benefits, including a reduction in cesarean deliveries and fewer preterm births as noted in observational studies of Medicaid populations, which ultimately lead to lower costs.^{8–10} Support during labor has also demonstrated decreased rates of cesarean deliveries in randomized trials.^{11–13} In addition to these improved obstetrical outcomes, continuous intrapartum

support and education from an individual not within the delivering person's network has demonstrated increased autonomy in decision making. Because the relationship between the doula and the delivering person is thought to contribute to maternal confidence and comfort, many programs, including ours, expand this support through the antenatal and postpartum periods. In recent years, several US states have made significant strides in expanding Medicaid coverage for doula services.¹⁴ For example, Oregon became the first state to provide Medicaid coverage for doula services in 2012. Since then, states such as Minnesota, Illinois, and New Jersey have followed suit. These policies highlight the growing acknowledgment of the

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AJOG at a Glance

Why was this study conducted?

This study aimed to quantify the association between doula care and obstetrical outcomes and to examine benefits specifically by race and insurer.

Key findings

Regardless of race or insurer, patients who received doula care were more likely to have a vaginal birth after a cesarean delivery, to attend their postpartum visit, to exclusively breastfeed, and to have fewer preterm births.

What does this add to what is known?

This study demonstrates the use of doulas in a population beyond the publicly insured. It also begins to quantify the clinical impact of doula care on maternal and neonatal outcomes for every 100 patients who received doula services.

importance of doula support and the commitment of states to address disparities in maternal and infant health through Medicaid coverage.

Although doulas are posited to have a significant impact on numerous maternal and neonatal outcomes and to decrease racial disparities, research that quantifies these effects is limited. Furthermore, the impact of doula support on the general population and the influence of race and payor status have been largely unexplored.

In this study, we aimed to evaluate if doula care, provided through our Birth Circle program, had an effect on a range of obstetrical and neonatal outcomes. We further evaluated if effects varied by patient race or type of insurance.

Materials and methods

Our study population included all live births at the Magee-Womens Hospital from January 2021 through December 2022. We limited the population to those who received any prenatal care within the University of Pittsburgh Medical Center (UPMC) health system. We removed from the analytical data set, deliveries with gestational ages of <16 weeks or >44 weeks at birth and those who received care from a doula outside of our program (n=67).

Our institution received funding support to develop the Birth Circle doula program, which integrates doula

care within the obstetrical team. In our program, doulas are employed directly by the health system. Doula care is provided without any financial cost to the patient. Patients can access doula care through provider referral, self-referral, or through directed outreach. All prenatal patients are made aware of the availability of doula services in routinely provided prenatal education materials at the initiation of prenatal care. Directed outreach involved additional communication to offer doula services to pregnant people who self-identified as Black, those who lived in a disadvantaged neighborhood (as defined by an Area Deprivation Index [ADI] > 90), those who were uninsured or insured by Medicaid, and those who were seeking care for their first pregnancy.

Exposure, outcome, and covariate data were captured using the UPMC's Clinical Data Warehouse (CDW). The CDW stored all discrete data documented in the electronic health records, as well as billing and registration data. Prenatal documentation, diagnoses at the time of delivery, and postpartum follow-up were included in this analysis.

This study was approved by the UPMC Quality Improvement approval committee (QI 3257).

Exposure

Patients were considered to have received doula care if they had at least 1

encounter with a doula, both prenatally and during delivery admission. In secondary analyses, doula care was redefined using only prenatal doula care; the exposure was limited to those persons with at least 3 (median) prenatal doula encounters, regardless of attendance of the doula at the time of delivery. Because doula care is not currently a reimbursable service in Pennsylvania, the Birth Circle doula program at our institution is grant funded to support the operations of the program and staff salaries and training.

Outcome and covariates

Maternal outcomes were captured at the time of delivery or within 6 weeks after delivery and included cesarean delivery; cesarean delivery of nulliparous, term, singleton, vertex infants (NTSV); successful vaginal birth after cesarean delivery (VBAC); gestational hypertension diagnosed after 20 weeks' gestation without chronic hypertension at the start of pregnancy; preeclampsia diagnosed after 20 weeks' gestation, postpartum emergency department (ED) visit, readmission, and attendance at a postpartum office visit.

Neonatal outcomes captured at the time of delivery included neonatal intensive care unit (NICU) admission, unexpected complications in term newborns (Perinatal Care metric 06 measures; details in [Supplemental Material \[https://manual.jointcommission.org/releases/TJC2019A/MIF0393.html\]](https://manual.jointcommission.org/releases/TJC2019A/MIF0393.html)), breastfeeding (exclusive or nonexclusive), preterm delivery (<37 weeks' gestation; indicated and spontaneous), and intrauterine growth restriction (IUGR). Secondary analyses also evaluated preterm delivery at <34, <32, and <28 weeks' gestation.

Analysis plan

We first compared prenatal, delivery, and postpartum characteristics by doula status using Pearson's chi-square tests, unpaired *t* tests, and Wilcoxon rank-sum tests as appropriate.

Our primary analysis consisted of 3 methodologic approaches in the full population. The first was a multivariate

logistic regression, followed by conditional logistic regressions in a propensity score–matched cohort and, third, a propensity score–adjusted logistic regression. All results were reported as the risk-adjusted frequency for every 100 deliveries with the associated risk difference and risk ratio for the comparison between those who received doula care and those who did not. Because doula services were promoted to nulliparous patients of Black race, those who lived in a neighborhood with an ADI >90, and those who were uninsured or publicly insured, we adjusted for these variables, along with the trimester in which care was initiated. Data that were missing at the time of the prenatal visit was populated with information from the time of delivery when available.

To generate propensity scores, the likelihood of receipt of doula care was modeled using a logistic regression. The variables included were captured at the time of first prenatal visit to best simulate the baseline characteristics of a clinical trial. Because doulas were promoted to those with a higher risk, outreach criteria were included a priori and forced into the model. Other variables, based on clinical judgement, included ethnicity, maternal age, chronic hypertension, morbid obesity, anxiety, depression, tobacco use, gestational hypertension, and preeclampsia.

The propensity score was evaluated by comparing the density of the score by doula status to ensure balance between the groups. Matching on propensity score was done in a 1:2 ratio (doula:no doula) with no replacement to ensure that the nearest neighbor within a caliper of 0.003 was matched.

Matching was evaluated by comparing the standardized percentage bias before and after matching, considering a bias <10% as acceptable.

To explore if associations with doula care varied by certain baseline demographics, we repeated each analysis in the following stratified populations: (1) self-reported Black vs White race

used as a proxy for racism and discrimination and (2) commercially insured vs publicly insured. New propensity scores were generated within racial and insurance groups. In sensitivity analyses, we redefined the definition of doula exposure to demonstrate engaged care. For this, we considered all patients with at least 3 doula encounters before delivery, regardless of doula attendance at delivery, as having received doula care. Propensity scores were recreated to model this exposure, and all 3 methodologic approaches were repeated.

Results

Of the 19,631 deliveries in the time frame, 17,831 were included in our cohort after excluding 147 with implausible gestational ages, 67 with other doula care, and 1582 with no prenatal care within UPMC. A total of 486 received doula care prenatally and at the time of delivery. The median amount of doula encounters was 5, and the majority of these occurred prenatally with 1 encounter at the time of delivery (Supplemental Material, Supplemental Figure 1, and Supplemental Figure 2). Those who received doula care were more likely to be Black, insured by Medicaid, reside in a more disadvantaged neighborhood, have more prenatal visits, have gestational hypertension diagnosed early in pregnancy, visit the ED, and be admitted prenatally (Table 1). At the time of delivery, patients with doula care had more frequent VBACs (34.4 vs 18.8%; $P=.002$), fewer preterm (7.2 vs 10.8%; $P=.012$) and early preterm deliveries (1.2 vs 3.3%; $P=.011$), fewer indicated preterm deliveries (3.3 vs 5.5%; $P=.035$), and had higher rates of exclusive breastfeeding (44.7 vs 37.1%; $P<.001$). In the postpartum period, those who delivered under doula care were more likely to attend an office visit within 6 weeks (83.1 vs 78.2%; $P=.010$).

Propensity scores were generated for 99.9% of the cohort. They were well balanced with even distribution by doula

status (Figure 1). The matched cohort included 969 controls that were matched to 485 patients who received doula care. All variables had a standardized bias of <10% after matching on propensity score (Figure 2).

In the primary analysis, of the 8 maternal outcomes evaluated, 2 demonstrated statistically significant improvement with doula care (Table 2). Specifically, VBACs and postpartum office visits were significantly increased. The results were similar in direction and significance regardless of methodologic approach. For every 100 patients who received doula care, there was an increase in additional VBACs that ranged from 15.6 (95% confidence interval [CI], 3.8–27.4) to 34.2 (95% CI, 0.046–68.0). Postpartum office follow-up adherence increased and ranged from an additional 5.4 (95% CI, 1.4–9.5) to 6.8 (95% CI, 3.7–9.9) visits per 100 patients who received care.

Of the 9 neonatal outcomes assessed, 3 demonstrated statistically significant improvements under doula care (Table 3). Exclusive breastfeeding increased by a range of 7.9 (95% CI, 2.7–13.0) to 11.4 (95% CI, 7.1–15.7) for every 100 patients who received doula care. Preterm birth decreased by in the range of –3.8 (95% CI, –6.1 to –1.5) to –4.0 (95% CI, –6.2 to –1.8) fewer preterm births per 100 deliveries that received doula care, and indicated preterm birth decreased by between –2.2 (95% CI, –3.8 to –0.56) and –2.7 (95% CI, –4.9 to –0.46). Statistically significant decreases in preterm delivery remained when reclassifying preterm as birth at <34, <32, or <28 weeks' gestation (data not shown). All other outcomes were not statistically significantly associated with doula care.

In secondary analyses, propensity scores were generated within the self-identified Black and White populations. Propensity scores were again well balanced with significant decreases in the standardized percentage bias before and after matching (Supplemental Material).

TABLE 1

Delivery characteristics of liveborn deliveries at the UPMC from January 1, 2021, through December 31, 2022, that also received prenatal care at the UPMC

Factor	No doula n (%)	Doula n (%)	P value ^a
No.	17,345	486	
Prenatal characteristics ^b			
Self-reported race			<.001
White	12,738 (73.4%)	276 (56.8%)	
Black	2941 (17.0%)	140 (28.8%)	
Other	1590 (9.2%)	65 (13.4%)	
Unknown	76 (0.4%)	5 (1.0%)	
Ethnicity			.14
Declined	910 (5.3%)	36 (7.5%)	
Hispanic or Latino	337 (2.0%)	12 (2.5%)	
Not Hispanic or Latino	15,926 (92.7%)	431 (90.0%)	
Not specified	2 (<1%)	0 (0.0%)	
Maternal age	30.6 (5.3)	30.9 (5.4)	.080
Insurance			.021
Commercial	12,091 (69.7%)	307 (63.2%)	
Medicaid	4960 (28.6%)	169 (34.8%)	
Medicare	106 (0.6%)	3 (0.6%)	
Self-pay or other	188 (1.1%)	7 (1.4%)	
Area Deprivation Index, mean (SD)	61.7 (24.7)	64.7 (24.4)	.009
Nulliparous	5334 (30.8%)	165 (34.0%)	.13
Gestational age at first visit, median (IQR)	64 (56–78)	63 (54–78)	.17
Trimester at first visit			
First	14,669 (84.6%)	407 (83.7%)	.93
Second	1791 (10.3%)	54 (11.1%)	
Third	881 (5.1%)	25 (5.1%)	
Number of prenatal visits	11 (9–13)	12 (10–14)	<.001
Pregavid weight (kg)	69 (61–84)	68 (59–84)	.19
Class III obesity (BMI ≥ 40 kg/m ²)	1101 (6.3%)	25 (5.1%)	.28
Chronic HTN	439 (2.5%)	11 (2.3%)	.71
Any gestational HTN	4600 (26.5%)	126 (25.9%)	.77
Preeclampsia	1600 (9.2%)	47 (9.7%)	.74
Diabetes T1/T2	177 (1.0%)	5 (1.0%)	.99
GDM	1561 (9.0%)	48 (9.9%)	.51
Anxiety	2491 (14.4%)	66 (13.6%)	.63
Depression	2231 (12.9%)	75 (15.4%)	.096
Tobacco use	1679 (9.7%)	36 (7.4%)	.094

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(continued)

In the subgroup of 3081 deliveries to Black patients, 140 received doula care (Supplemental Table 1). Crude trends were similar, although, in addition, Black patients who received doula care sought prenatal care earlier (gestational age at pregnancy start of 61 vs 66 days; $P=.003$) and had more antenatal (67.9 vs 53.5%; $P<.001$) and postpartum ED visits (18.6 vs 12.4%; $P=.031$) than those who did not receive doula care. Antepartum hospital use rates were much higher in this population than in the White population. The modeled outcomes were similar in direction, but preterm birth was no longer statistically significant (Supplemental Tables 2 and 3). There were 13,014 deliveries to patients who self-identified as White and 276 of those received doula care (Supplemental Table 4). Although White patients with doula care were more likely to be Hispanic or Latino (4.0 vs 1.7%; $P=.002$), the baseline differences between those who received and those who did not receive doula care were consistent with the full population. Modeled outcomes demonstrate a consistent increase in VBACs, postpartum office visits, and exclusive breastfeeding rates, along with marked decreases in preterm birth (Supplemental Tables 5 and 6).

There were 12,398 commercially insured deliveries, and 307 of those received doula care (Supplemental Table 7). The crude trends were again similar to those of the full population; however, in addition, those who received doula care in this population had lower pregravid weights (145 vs 151 pounds; $P=.011$), more frequently had depression (13.7 vs 10.0%; $P=.033$), and were more likely to be diagnosed with IUGR at the time of delivery (4.2 vs 2.4%; $P=.043$). The modeled outcomes were similar to those of the full population in direction and significance (Supplemental Tables 8 and 9).

Of the 5238 deliveries to publicly insured patients, 172 received doula care (Supplemental Table 10). The crude trends were aligned with those of the full population, however, the ADI did not vary by doula status. The modeled outcomes were less stable in

TABLE 1

Delivery characteristics of liveborn deliveries at the UPMC from January 1, 2021, through December 31, 2022, that also received prenatal care at the UPMC (continued)

Factor	No doula n (%)	Doula n (%)	P value ^a
Antepartum ED visit	4592 (26.5%)	178 (36.6%)	<.001
Antepartum admission	1337 (7.7%)	50 (10.3%)	.036
Delivery characteristics			
CD	5779 (33.3%)	155 (31.9%)	.51
NTSV CD ^c	1645 (27.4%)	69 (29.9%)	.341
VBAC ^d	579 (18.8%)	22 (34.4%)	.002
Maternal length of stay (d)	2.5 (2.1–3.2)	2.9 (2.3–3.5)	<.001
Maternal delivery weight	156.8 (135–189)	154 (133.4–191)	.25
Birth weight ^e	3260 (2910–3590)	3250 (2910–3610)	.82
IUGR	582 (3.4%)	23 (4.7%)	.098
PTB (<37 wk)	1865 (10.8%)	35 (7.2%)	.012
EPTB (<34 wk)	577 (3.3%)	6 (1.2%)	.011
VEPTB (<28 wk)	195 (1.1%)	1 (0.2%)	.055
Indicated PTB	952 (5.5%)	16 (3.3%)	.035
Spontaneous PTB	913 (5.3%)	19 (3.9%)	.19
Overall Inductions	6890 (39.7%)	183 (37.7%)	.36
Obstetrical HTN diagnosis	4197 (24.2%)	117 (24.1%)	.95
Preeclampsia	1505 (8.7%)	46 (9.5%)	.54
SMM	498 (2.9%)	15 (3.1%)	.78
NICU at the time of delivery	2803 (16.3%)	68 (14.0%)	.19
Unexpected complications in term newborns ^f	293 (2.2%)	9 (2.3%)	.89
Moderate	210 (1.6%)	7 (1.8%)	.74
Severe	179 (1.4%)	5 (1.3%)	.91
Exclusive breastfeeding at discharge	6429 (37.1%)	217 (44.7%)	<.001
Postpartum follow-up ^g			
Office visit	13,572 (78.2%)	404 (83.1%)	.010
ED visit	1524 (8.8%)	53 (10.9%)	.10
Postpartum readmission	878 (5.1%)	28 (5.8%)	.49

The results for n=17,831 deliveries are presented.

BMI, body mass index; CD, cesarean delivery; ED, emergency department; EPTB, early preterm birth; GDM, gestational diabetes; HTN, hypertension; IQR, interquartile range; IUGR, intrauterine growth restriction; NICU, neonatal intensive care unit; NTSV, nulliparous, term, singleton, vertex; PC06, Perinatal Care metric 06; PTB, preterm birth; SD, standard deviation; SMM, severe maternal morbidity; UPMC, University of Pittsburgh Medical Center; VBAC, vaginal birth after cesarean; VEPTB, very early preterm birth.

^a Pearson's chi-square tests, 2-sample t tests, and Wilcoxon rank-sum tests were used to determine P values as appropriate;

^b Missing variables at prenatal visit were filled with those populated at the time of delivery when available; ^c Denominator limited to NTSV eligible (n=6007 in no doula; 231 in doula); ^d Denominator limited to deliveries with previous cesarean delivery (n=3088 in no doula; 64 in doula); ^e Birth weight reflective of smallest infant in multiples; ^f Denominator limited to PC06 eligible (n=13,260 in no doula; 389 in doula); ^g Within 6 weeks of delivery.

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this smaller population; however, trends toward increased VBAC, adherence to postpartum office visit, exclusive breastfeeding rates, and decreased preterm births persisted, however, these were not all statistically significant (Supplemental Tables 11 and 12).

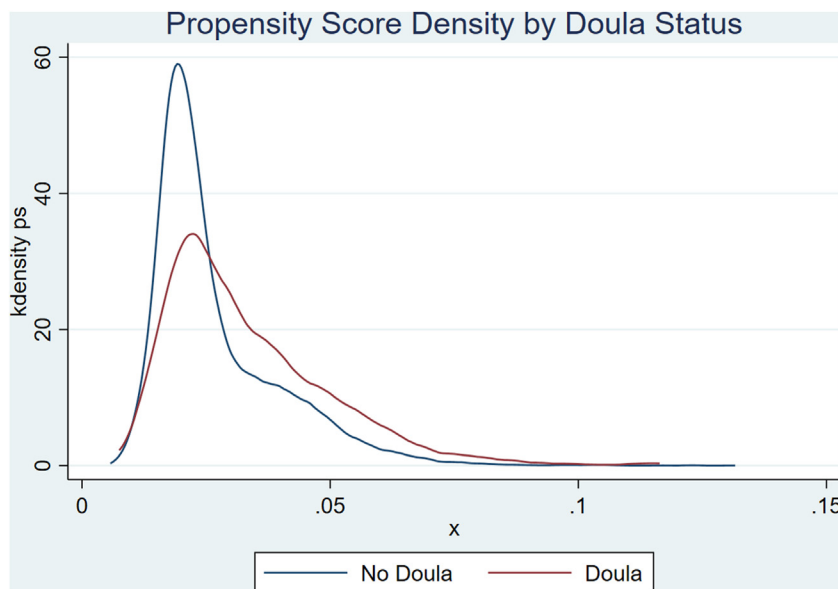
Refining the classification of doula care to only evaluate patients who had at least 3 doula encounters prenatally produced a cohort of 483 patients who received doula care (Supplemental Table 13). The differences when using the refined definition of doula care were that patients who received doula care more frequently had depression and had significantly more postpartum ED visits (8.8 vs 11.4%; $P=.046$) (Supplemental Table 13). The analyses demonstrated similar trends as observed for the original cohort, however, patients who received doula care had significantly lower spontaneous preterm birth rates, rather than indicated, than patients who did not receive doula care (Supplemental Tables 14 and 15).

Comment Principal findings

In this study, we found that receiving doula care was associated with increased odds of VBAC, attendance of postpartum office visits, and exclusively breastfeeding rates. Those patients who received doula care prenatally and at the time of delivery also had significantly decreased odds of preterm births. These benefits persisted regardless of race or insurance type.

Results in the context of what is known

Our findings that showed fewer cesarean and preterm deliveries among patients who received doula care are consistent with the literature^{6,8,9,13}; however, we only demonstrated a statistically significant increase in VBACs and not a decrease in all cesarean deliveries as has been demonstrated previously. Although directionally similar,

FIGURE 1
Propensity score distribution by doula status

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this lack of statistical significance may be because we did not limit the cohort to full-term deliveries only and we expanded the cohort to include patients who were commercially insured.¹⁰

Although many studies that demonstrated benefit were randomized controlled trials,^{11–13} the gold standard, these studies were small. Furthermore, we used rigorous

methods beyond multivariable regressions to create an appropriate referent group and to reduce the likelihood of confounding by variables that influence the likelihood of receiving doula care. We also expanded this research by quantifying the association with breastfeeding and compliance with postpartum follow-up.

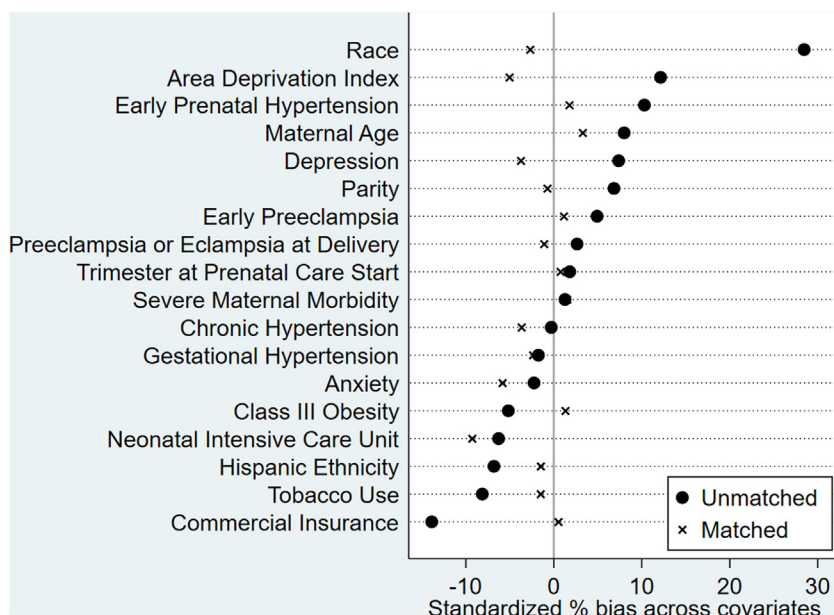
Clinical implications

The outcomes associated with doula care in this study carry clinical, quality of life, and financial benefits. For example, VBACs have been proven to lead to less maternal morbidities in current and future pregnancies¹⁵ and the average lengths of stay at our institution for patients who underwent vaginal deliveries were shorter than those who underwent cesarean deliveries. Breastfeeding benefits both the mother and the infant in terms of increased bonding, lower long-term maternal cancer risk, and avoiding the costs of formula.^{16,17} Finally, preterm birth remains the leading cause of mortality in children under 5 years¹⁸ and is a costly outcome to both the health system and the family.^{19,20}

The improved clinical outcomes, paired with potential cost savings, may make these programs beneficial at a patient and system level. Our results support advocating for continued grant funding and expansion to include doulas as a covered service for all patients regardless of insurance status.

Research implications

Patients cared for by a doula feel more supported and empowered,¹³ and this likely leads to decisions to attempt a VBAC, to choose breastfeeding, and to engage in postpartum care. Our sensitivity analysis supports this idea by demonstrating that the strength of the associations were similar when defining doula care as 3 or more prenatal encounters, but not requiring a doula's presence at delivery. Our future work will focus on how best to capture and quantify the amount and type of care provided by the doula. We plan to conduct focus groups and to use qualitative and mixed methods to explore the perspectives of both the patient and the

FIGURE 2
Bias before and after matching on propensity score

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TABLE 2
Risk-adjusted frequency of maternal outcomes

Model	No.	Total visits/total, n (%)		Risk-adjusted ^a frequency per 100 deliveries (95% CI)		Risk difference, per 100 deliveries (95% CI)	Risk ratio (95% CI)
		Doula	No doula	Doula	No doula		
Cesarean delivery							
Crude	5934	155/486 (31.9)	5779/17,345 (33.3)	31.6 (27.5—35.8)	33.3 (32.6—34.0)	−1.7 (−5.9 to 2.5)	0.95 (0.83—1.09)
PS-matched ^b	471	154/485 (31.8)	317/969 (32.7)	31.8 (27.6—35.9)	32.7 (29.8—35.7)	−0.91 (−6.0 to 4.2)	0.97 (0.83—1.14)
PS-adjusted ^c	5294	155/486 (31.9)	5769/17,324 (33.3)	30.7 (26.7—34.8)	33.3 (32.6—34.0)	−2.6 (−6.7 to 1.5)	0.92 (0.81—1.05)
NTSV cesarean delivery ^d							
Crude	1714	69/231 (29.9)	1645/6007 (27.4)	30.2 (24.2—36.2)	27.4 (26.3—28.5)	2.8 (−3.2 to 8.9)	1.10 (0.90—1.35)
PS-matched ^b	169	69/231 (29.9)	100/360 (29.9)	29.7 (23.8—35.7)	27.9 (23.2—32.5)	1.9 (−5.8 to 9.5)	1.07 (0.82—1.39)
PS-adjusted ^c	1711	69/231 (29.9)	1642/6001 (27.4)	28.6 (22.8—34.3)	27.4 (26.3—28.5)	1.2 (−4.7 to 7.0)	1.04 (0.85—1.28)
VBAC ^e							
Crude	601	22/64 (34.4)	579/3088 (18.8)	52.8 (19.3—86.3)	18.6 (17.2—20.0)	34.2 (0.046—68.0)	2.8 (1.48—5.44)
PS-matched ^b	59	22/64 (34.4)	37/170 (21.8)	34.6 (22.8—46.5)	21.7 (15.5—27.9)	13.0 (−0.53 to 26.4)	1.60 (1.02—2.50)
PS-adjusted ^c	599	22/64 (34.4)	577/3081 (18.7)	34.3 (22.6—46.0)	18.7 (17.4—20.1)	15.6 (3.8—27.4)	1.83 (1.29—2.60)
Hypertension after 20 wk							
Crude	3563	82/486 (16.9)	3481/17,345 (20.1)	17.1 (13.7—20.5)	20.1 (19.5—20.7)	−3.0 (−6.4 to 0.44)	0.85 (0.70—1.04)
PS-matched ^b	268	82/485 (16.9)	186/969 (19.2)	17.0 (13.6—20.3)	19.2 (16.7—21.6)	−2.2 (−6.3 to 1.9)	0.89 (0.70—1.12)
PS-adjusted	3560	82/486 (16.9)	3478/17,324 (20.1)	17.5 (14.0—20.9)	20.1 (19.5—20.7)	−2.6 (−6.1 to 0.88)	0.87 (0.71—1.06)
Preeclampsia after 20 wk							
Crude	1540	42/486 (8.6)	1498/17,345 (8.6)	8.5 (6.0—10.9)	8.7 (8.2—9.1)	−0.16 (−2.7 to 2.3)	0.98 (0.73—1.32)
PS-matched ^b	135	42/486 (8.7)	93/969 (9.6)	8.8 (6.3—11.3)	9.5 (7.7—11.4)	−0.77 (−3.9 to 2.3)	0.92 (0.65—1.30)
PS-adjusted	1536	42/486 (8.6)	1494/17,324 (8.6)	8.1 (5.7—10.5)	8.6 (8.2—9.1)	−0.53 (−2.9 to 1.9)	0.94 (0.70—1.26)
Postpartum EDTR							
Crude	1577	53/486 (10.9)	1524/17,345 (8.8)	10.5 (7.8—13.2)	8.8 (8.4—9.2)	1.7 (−1.0 to 4.4)	1.19 (0.92—1.54)
PS-matched ^b	157	53/485 (10.9)	104/969 (10.7)	11.1 (8.3—13.8)	10.7 (8.7—12.6)	0.38 (−3.0 to 3.8)	1.04 (0.76—1.4)
PS-adjusted ^c	1577	53/486 (10.9)	1524/17,324 (8.8)	10.4 (7.7—13.1)	8.8 (8.4—9.2)	1.6 (−1.1 to 4.3)	1.18 (0.91—1.53)
Postpartum readmission							
Crude	906	28/486 (5.8)	878/17,345 (5.1)	5.6 (3.6—7.6)	5.1 (4.7—5.4)	0.54 (−1.5 to 2.6)	1.12 (0.77—1.59)
PS-matched ^b	72	28/485 (5.8)	44/969 (4.5)	5.8 (3.7—7.9)	4.5 (3.2—5.8)	1.3 (−1.2 to 3.7)	1.28 (0.81—2.03)
PS-adjusted	906	28/486 (5.8)	878/17,324 (5.2)	5.5 (3.5—7.5)	5.1 (4.8—5.4)	0.42 (−1.6 to 2.4)	1.08 (0.75—1.56)

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(continued)

TABLE 2 Risk-adjusted frequency of maternal outcomes (continued)							
Model	No.	Total visits/total, n (%)		Risk-adjusted ^a frequency per 100 deliveries (95% CI)		Risk difference, per 100 deliveries (95% CI)	Risk ratio (95% CI)
		Doula	No doula	Doula	No doula		
Postpartum office visit							
Crude	13,976	404/486 (83.1)	13572/17,345 (78.3)	84.8 (81.9–87.7)	78.2 (77.6–78.8)	6.7 (3.7–9.6)	1.09 (1.05–1.12)
PS-matched ^b	1151	404/485 (83.3)	747/969 (77.1)	82.8 (79.6–86.0)	77.4 (74.9–79.9)	5.4 (1.4–9.5)	1.07 (1.02–1.13)
PS-adjusted ^c	13,963	404/486 (83.1)	13559/17,324 (78.3)	85.0 (82.0–88.0)	82.2 (77.6–78.8)	6.8 (3.7–9.9)	1.09 (1.05–1.13)
CI, confidence interval; EDTR, emergency department treat and release; NTSV, nulliparous, term, singleton, vertex; PS, propensity score; VBAC, vaginal birth after cesarean.							
^a Adjusted for race, insurance type, ADI, nulliparity, and trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula: doula) on propensity score; ^c Adjusted for propensity score and interaction between doula care with race and with insurance type; ^d Limited to NTSV deliveries; ^e Limited to deliveries with a previous cesarean delivery.							
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doula. Ideally, together, this would elucidate the mechanisms that underlie the relationship between doula care and lower odds of preterm delivery in future studies, particularly addressing the difference between spontaneous and indicated preterm deliveries. The possibility of savings or cost avoidance is another area that deserves exploration in future work.

Strengths and limitations

Using the CDW provided large, readily available population data, although it was limited to information captured primarily in the electronic health records. Other indicators of social determinants of health, such as employment and housing, were not discretely documented and were therefore not available for the analysis. We used ADI, a widely used marker of neighborhood advantage,²¹ to address this limitation. Our electronic health records also lacked discrete documentation of trial of labor. This limits reporting to successful VBACs rather than attempted, which would be more indicative of patient decision. Finally, although doulas were offered to all patients, there was preferential promotion to patients at higher risk for poor maternal outcomes, thereby potentially masking benefit—similar to confounding by indication. We overcame this bias by using propensity scores and multiple methodologic approaches to demonstrate the robustness of our results. Although confounding by other unmeasured variables may remain, our approach would likely only have underestimated the benefit if confounding persists. Using our stratified approach, we also have lower power to detect statistical significance, particularly because our institution had 3081 deliveries to Black patients as opposed to 13,014 deliveries to White patients.

Conclusion

Although our findings reaffirm the possibility of benefit of doula care for delivering persons with public insurance that were presented in previous studies, in addition, they demonstrated

TABLE 3
Risk-adjusted frequency of neonatal outcomes

Model	No.	Total visits/total, n (%)		Risk-adjusted ^a frequency per 100 deliveries (95% CI)		Risk difference, per 100 deliveries (95% CI)	Risk ratio (95% CI)
		Doula	No doula	Doula	No doula		
NICU ^b							
Crude	2871	68/484 (14.1)	2803/17,195 (16.3)	13.8 (10.8–16.8)	16.3 (15.8–16.9)	−2.5 (−5.6 to 0.57)	0.85 (0.68–1.06)
PS-matched ^c	225	67/483 (13.9)	158/959 (16.5)	13.9 (10.8–17.0)	16.5 (14.1–18.8)	−2.6 (−6.4 to 1.3)	0.84 (0.65–1.10)
PS-adjusted	2866	68/484 (14.1)	2798/17,174 (16.3)	13.7 (10.7–16.7)	16.3 (15.8–16.9)	−2.6 (−5.7 to 0.48)	0.84 (0.67–1.05)
Unexpected severe complication in term newborn ^d							
Crude	184	5/389 (1.3)	179/13,260 (1.4)	1.2 (0.16–2.3)	1.4 (1.2–1.6)	−0.01 (−1.2 to 0.99)	0.92 (0.38–2.22)
PS-matched ^c	13	5/389 (1.3)	8/712 (1.1)	1.3 (0.16–2.3)	1.1 (0.36–1.9)	0.10 (−1.2 to 1.4)	1.09 (0.36–3.30)
PS-adjusted	184	5/389 (1.3)	179/13,246 (1.4)	1.3 (0.16–2.4)	1.4 (1.2–1.6)	−0.06 (−1.2 to 1.1)	0.96 (0.39–2.32)
Unexpected moderate complication in term newborn ^d							
Crude	217	7/389 (1.8)	210/13,260 (1.6)	1.8 (0.47–3.1)	1.6 (1.4–1.8)	0.19 (−1.1 to 1.5)	1.12 (0.53–2.36)
PS-matched ^c	17	7/389 (1.8)	10/712 (1.4)	1.8 (0.50–3.2)	1.4 (0.54–2.2)	0.44 (−1.1 to 2.0)	1.32 (0.51–3.42)
PS-adjusted	216	7/389 (1.8)	209/13,246 (1.6)	1.8 (0.48–3.2)	1.6 (1.4–1.8)	0.24 (−1.1 to 1.6)	1.15 (0.54–2.43)
Breastfeeding							
Exclusive							
Crude	6646	217/486 (44.7)	6429/17,345 (37.1)	48.4 (44.1–52.6)	37.0 (36.3–37.7)	11.4 (7.1–15.7)	1.31 (1.20–1.43)
PS-matched ^c	567	217/485 (44.7)	350/969 (36.1)	44.2 (40.0–48.4)	36.4 (33.4–39.3)	7.9 (2.7–13.0)	1.22 (1.07–1.38)
PS-adjusted	6643	217/486 (44.7)	6426/17,324 (37.1)	53.4 (48.7–58.6)	43.6 (42.7–44.4)	10.1 (5.1–15.1)	1.23 (1.12–1.35)
Nonexclusive							
Crude	7541	229/486 (47.1)	7312/17,345 (42.2)	44.9 (40.6–49.3)	42.2 (41.5–42.9)	2.7 (−1.7 to 7.2)	1.06 (0.96–1.18)
PS-matched ^c	656	228/485 (47.1)	428/969 (44.2)	47.2 (42.8–51.6)	44.1 (41.0–47.2)	3.1 (−2.3 to 8.5)	1.07 (0.95–1.20)
PS-adjusted	7528	229/486 (47.1)	7299/17,324 (42.1)	44.2 (39.8–48.6)	42.2 (41.5–42.9)	2.0 (−2.4 to 6.5)	1.05 (0.95–1.16)
PTB							
Overall							
Crude	1900	35/486 (7.2)	1865/17,345 (10.8)	7.0 (4.8–9.2)	10.8 (10.3–11.2)	−3.8 (−6.1 to −1.5)	0.65 (0.47–0.89)
PS-matched ^c	145	35/485 (7.2)	110/969 (11.4)	7.3 (5.0–9.7)	11.3 (9.3–13.2)	−3.9 (−7.0 to −0.86)	0.65 (0.45–0.94)
PS-adjusted	1896	35/486 (7.2)	1861/17,324 (10.7)	6.8 (4.6–8.9)	10.8 (10.3–11.2)	−4.0 (−6.2 to −1.8)	0.63 (0.45–0.87)

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(continued)

TABLE 3
Risk-adjusted frequency of neonatal outcomes (continued)

Model	No.	Total visits/total, n (%)		Risk-adjusted ^a frequency per 100 deliveries (95% CI)		Risk difference, per 100 deliveries (95% CI)	Risk ratio (95% CI)
		Doula	No doula	Doula	No doula		
Spontaneous							
Crude	932	19/486 (3.9)	913/17,345 (5.3)	3.8 (2.1–5.4)	5.3 (4.9–5.6)	–1.5 (–3.2 to 0.17)	0.71 (0.46–1.11)
PS-matched ^c	70	19/485 (3.9)	51/959 (5.3)	4.0 (2.2–5.7)	5.2 (3.8–6.6)	–1.3 (–3.5 to 0.99)	0.76 (0.46–1.27)
PS-adjusted	932	19/486 (3.9)	912/17,324 (5.3)	3.9 (2.2–5.6)	5.3 (4.9–5.6)	–1.4 (–3.1 to 0.40)	0.74 (0.48–1.16)
Indicated							
Crude	968	16/486 (3.3)	952/17,345 (5.5)	3.2 (1.7–4.8)	5.5 (5.2–5.8)	–2.3 (–3.9 to –0.69)	0.59 (0.36–0.95)
PS-matched ^c	75	16/486 (3.3)	59/969 (6.1)	3.4 (1.8–5.0)	6.0 (4.5–7.5)	–2.7 (–4.9 to –0.46)	0.56 (0.33–0.96)
PS-adjusted	965	16/486 (3.3)	949/17,324 (5.5)	3.3 (1.7–4.9)	5.5 (5.1–5.8)	–2.2 (–3.8 to –0.56)	0.60 (0.37–0.98)
IUGR diagnosis							
Crude	605	23/486 (4.7)	582/17,345 (3.4)	4.4 (2.6–6.1)	3.4 (3.1–3.6)	1.0 (–0.76 to 2.8)	1.30 (0.86–1.95)
PS-matched ^c	59	22/485 (4.5)	37/969 (3.8)	4.6 (2.7–6.5)	3.8 (2.6–5.0)	0.80 (–1.4 to 3.0)	1.21 (0.72–2.03)
PS-adjusted	603	23/486 (4.7)	580/17,324 (3.4)	4.7 (2.8–6.6)	3.4 (3.1–3.6)	1.4 (–0.52 to 3.3)	1.41 (0.94–2.12)

CI, confidence interval; IUGR, intrauterine growth restriction; NICU, neonatal intensive care unit; PC06, Perinatal Care metric 06; PS, propensity score; PTB, preterm birth.

^a Adjusted for race, insurance type, ADI, nulliparity, and trimester, all at the time of the first prenatal visit; ^b A total of 152 with missing NICU status (n=17,679 for that analysis); ^c Matched 2:1 (no doula: doula) on propensity score; ^d Only those deemed eligible by PC06 definitions were included in the denominator. Specifically, deliveries with liveborn, term singletons, ≥2500 g, with no congenital malformations or preexisting fetal conditions, nor maternal drug use.

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additional benefits and that those also extend to commercially insured patients. This has the potential to improve the cost savings and afford the opportunity for self-supporting doula programs. ■

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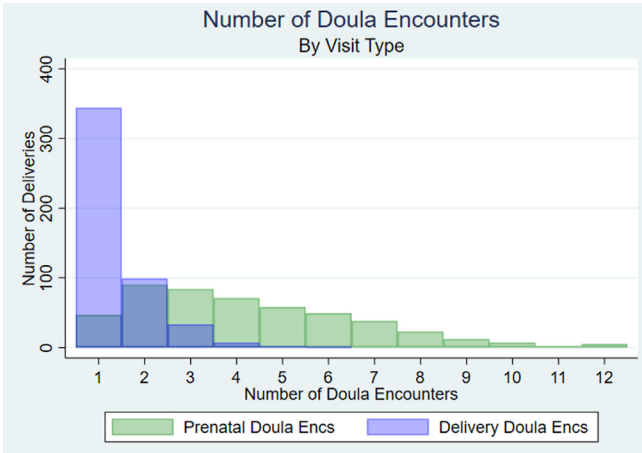
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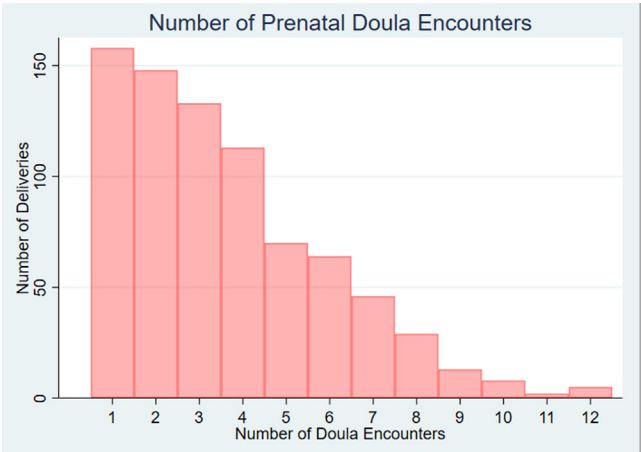
Details of Propensity Score:
Variables included documented at time of first prenatal visit: race, ethnicity, insurance type, primiparity, area deprivation index, gestational age, maternal age, chronic hypertension, morbid obesity, anxiety, depression, tobacco use, gestaional hypertension, preeclampsia.

SFIGURE 1
Count of number of doula encounters by patient, prenatally and at time of delivery



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SFIGURE 2
Number of prenatal doula encounters in patients with any prenatal doula care



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Results stratified by self-reported race

STABLE 1

Delivery characteristics of liveborn deliveries to Black patients at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n = 3,081)

Factor	No Doula n (%)	Doula n (%)	p-value ^b
N	2941	140	
<i>Prenatal Characteristics^a</i>			
Ethnicity			0.48
Declined	200 (6.8%)	8 (5.7%)	
Hispanic or Latino	25 (0.9%)	0 (0.0%)	
Not Hispanic or Latino	2712 (92.3%)	132 (94.3%)	
Maternal age	27.8 (5.9)	28.5 (5.9)	0.16
Insurance			0.67
Commercial	946 (32.2%)	40 (28.6%)	
Medicaid	1941 (66.0%)	98 (70.0%)	
Medicare	41 (1.4%)	1 (0.7%)	
Self-Pay/ Other	13 (0.4%)	1 (0.7%)	
Area Deprivation Index [Mean (SD)]	83.2 (18.0)	80.9 (20.0)	0.14
Nulliparous	792 (26.9%)	42 (30.0%)	0.42
Gestational age at first visit [Median (IQR)]	66 (54, 92)	61 (48.5, 75.5)	0.003
Trimester at first visit			
First	2280 (77.5%)	118 (84.3%)	0.17
Second	496 (16.9%)	16 (11.4%)	
Third	165 (5.6%)	6 (4.3%)	
Number of prenatal visits	10 (7, 13)	12 (9, 15)	<0.001
Pregravid weight (lbs)	167 (137, 205)	170 (131, 205)	0.92
Morbidly obese	289 (9.8%)	12 (8.6%)	0.63
Chronic HTN	138 (4.7%)	7 (5.0%)	0.87
Any gestational HTN	526 (17.9%)	34 (24.3%)	0.055
Prior to 20 weeks ^c	166 (5.6%)	15 (10.7%)	0.013
After 20 weeks	612 (20.8%)	27 (19.3%)	0.66
Preeclampsia	67 (2.3%)	5 (3.6%)	0.32
Prior to 20 weeks	21 (0.7%)	3 (2.1%)	0.060
After 20 weeks	320 (10.9%)	17 (12.1%)	0.64
Diabetes T1/T2	37 (1.3%)	1 (0.7%)	0.57
GDM	218 (7.4%)	11 (7.9%)	0.84
Anxiety	271 (9.2%)	16 (11.4%)	0.38
Depression	446 (15.2%)	23 (16.4%)	0.68
Tobacco use	492 (16.7%)	18 (12.9%)	0.23
Antepartum ED	1574 (53.5%)	95 (67.9%)	<0.001
Antepartum admission	359 (12.2%)	26 (18.6%)	0.026

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(continued)

STABLE 1

Delivery characteristics of liveborn deliveries to Black patients at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n=3,081) (continued)

Factor	No Doula n (%)	Doula n (%)	p-value ^b
<i>Delivery Characteristics</i>			
C-Section	980 (33.3%)	40 (28.6%)	0.24
NTSV Cesarean ^d	260 (31.6%)	18 (33.3%)	0.79
VBAC	129 (22.4%)	9 (39.1%)	0.062
Maternal delivery weight	171 (141, 208.9)	180.2 (141.4, 210)	0.70
Birthweight ^e	3080 (2727, 3420)	3060 (2760, 3390)	0.88
IUGR	156 (5.3%)	10 (7.1%)	0.35
PTB (<37 weeks)	408 (13.9%)	16 (11.4%)	0.41
EPTB (<34 weeks)	157 (5.3%)	3 (2.1%)	0.096
VEPTB (<28 weeks)	62 (2.1%)	1 (0.7%)	0.25
Indicated PTB	197 (6.7%)	7 (5.0%)	0.43
Spontaneous PTB	211 (7.2%)	9 (6.4%)	0.74
Overall Inductions	1150 (39.1%)	59 (42.1%)	0.47
Obstetric HTN diagnosis	834 (28.4%)	44 (31.4%)	0.43
Preeclampsia	326 (11.1%)	20 (14.3%)	0.24
SMM	124 (4.2%)	6 (4.3%)	0.97
NICU at time of delivery	556 (19.1%)	18 (12.9%)	0.070
Unexpected complication in term newborn ^f	43 (2.1%)	2 (2.0%)	0.94
Moderate	24 (1.2%)	1 (1.0%)	0.87
Severe	28 (1.4%)	1 (1.0%)	0.75
<i>Postpartum follow-up^g</i>			
Office Visit	1647 (56.0%)	95 (67.9%)	0.006
EDTR	364 (12.4%)	26 (18.6%)	0.031
Postpartum readmission	215 (7.3%)	11 (7.9%)	0.81

SD=standard deviation; IQR=interquartile range; HTN=hypertension; GDM=gestational diabetes; ED=emergency department; NTSV=nulliparous, term, singleton, vertex; VBAC=vaginal birth after cesarean; IUGR=intrauterine growth restriction; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; NICU=neonatal intensive care unit; PC06= Perinatal Care metric 06.

^a Missingness of variables at prenatal visit are filled in with those populated at time of delivery when available; ^b Pearson's chi-squared, Two sample t test, Wilcoxon rank sum as appropriate;

^c Excludes chronic hypertension; ^d Denominator limited to NTSV eligible (n=6029 in no doula; 232 in doula); ^e Birthweight reflective of smallest infant for multiples; ^f Denominator limited to PC06 eligible (n=13317 in no doula; 391 in doula); ^g Within 6 weeks of delivery.

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STABLE 2

Risk-Adjusted frequency of maternal outcomes for self-reported black patients

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
Cesarean Delivery							
Crude	1020	40/140 (28.6)	980/2941 (33.3)	28.2 (20.9, 35.7)	33.3 (31.6, 35.0)	-5.1 (-12.7, 2.6)	0.85 (0.65, 1.11)
PS-matched ^b	125	39/139 (28.1)	86/276 (31.2)	28.1 (20.7, 35.5)	31.2 (257, 36.6)	-3.1 (-12.3, 6.1)	0.90 (0.66, 1.24)
PS-adjusted	1008	40/140 (28.6)	968/2912 (33.2)	26.9 (19.6, 34.1)	33.3 (31.6, 35.0)	-6.5 (-13.9, 0.96)	0.81 (0.61, 1.06)
NTSV Cesarean Delivery ^c							
Crude	278	18/54 (33.3)	260/824 (31.6)	33.7 (21.0, 46.3)	31.5 (28.4, 34.7)	2.1 (-10.9, 15.2)	1.07 (0.72, 1.57)
PS-matched ^b	44	18/54 (33.3)	26/85 (30.6)	32.6 (20.2, 45.0)	31.0 (21.3, 40.8)	1.6 (-14.4, 17.5)	1.05 (0.64, 1.73)
PS-adjusted	278	18/54 (33.3)	260/820 (31.7)	32.6 (20.1, 45.0)	31.8 (28.6, 34.9)	0.80 (-12.1, 13.7)	1.03 (0.69, 1.52)
VBAC ^d							
Crude	138	9/23 (39.1)	129/576 (22.4)	39.4 (19.4, 59.3)	22.4 (19.0, 25.8)	17.0 (-3.3, 37.2)	1.76 (1.04, 2.98)
PS-matched ^b	21	9/22 (40.9)	12/48 (25.0)	40.8 (20.8, 30.9)	24.9 (12.8, 37.1)	15.9 (-7.7, 39.4)	1.64 (0.82, 3.28)
PS-adjusted	134	9/23 (39.1)	125/565 (22.1)	42.6 (21.8, 63.4)	22.0 (18.6, 25.4)	20.6 (-0.58, 41.7)	1.93 (1.16 3.23)
Late hypertension							
Crude	639	27/140 (19.3)	612/2941 (20.8)	19.2 (12.7, 25.6)	20.8 (19.4, 22.3)	-1.7 (-8.3, 5.0)	0.92 (0.65, 1.30)
PS-matched ^b	87	27/139 (19.4)	60/276 (21.7)	19.3 (12.8, 25.7)	21.8 (17.0, 26.6)	-2.5 (-10.6, 5.5)	0.88 (0.59, 1.32)
PS-adjusted	632	27/140 (19.3)	605/2912 (20.8)	20.1 (13.3, 26.8)	20.7 (19.3, 22.2)	-0.68 (-7.6, 6.2)	0.97 (0.69, 1.36)
Late preeclampsia							
Crude	337	17/140 (12.1)	320/2941 (10.9)	12.0 (6.6, 17.3)	10.9 (9.8, 12.0)	1.1 (-4.4, 6.5)	1.10 (0.70, 1.74)
PS-matched ^b	52	17/139 (12.2)	35/276 (12.7)	12.1 (6.7, 17.5)	12.7 (8.8, 16.7)	-0.63 (-7.3, 6.0)	0.95 (0.55, 1.63)
PS-adjusted	331	17/140 (12.1)	314/2912 (10.8)	10.5 (5.7, 15.3)	10.9 (9.7, 12.0)	-0.41 (-5.3, 4.5)	0.96 (0.60, 1.54)
Postpartum EDTR							
Crude	390	26/140 (18.6)	364/2941 (12.4)	18.6 (12.2, 25.1)	12.4 (11.2, 13.6)	6.3 (-0.31, 12.8)	1.51 (1.05, 2.16)
PS-matched ^b	65	26/139 (18.7)	39/276 (14.1)	18.7 (12.2, 25.1)	14.2 (10.0, 18.3)	4.5 (-3.2, 12.2)	1.32 (0.84, 2.07)
PS-adjusted	383	26/140 (18.6)	357/2912 (12.3)	18.6 (12.1, 25.1)	12.3 (11.1, 13.5)	6.4 (-0.25, 13.0)	1.52 (1.06, 2.18)
Postpartum Readmission							
Crude	226	11/140 (7.9)	215/2941 (7.3)	7.8 (3.4, 12.3)	7.3 (6.4, 8.3)	0.53 (-4.0, 5.1)	1.07 (0.60, 1.92)
PS-matched ^b	35	11/139 (7.9)	24/276 (8.7)	8.0 (3.5, 12.5)	8.7 (5.4, 12.0)	-0.69 (-6.3, 4.9)	0.92 (0.47, 1.82)

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(continued)

STABLE 2
Risk-Adjusted frequency of maternal outcomes for self-reported black patients (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
PS-adjusted	224	11/140 (7.9)	213/2912 (7.3)	7.5 (3.2, 11.8)	7.3 (6.4, 8.3)	0.19 (-4.2, 4.6)	1.03 (0.57, 1.85)
<i>Postpartum Office Visit</i>							
Crude	1742	95/140 (67.9)	1647/2941 (56.0)	67.4 (59.9, 75.0)	56.0 (54.3, 57.8)	11.4 (3.7, 19.2)	1.20 (1.07, 1.35)
PS-matched ^b	266	94/139 (67.6)	172/276 (62.3)	67.7 (60.1, 75.4)	62.3 (56.7, 67.9)	5.5 (-4.0, 14.9)	1.09 (0.94, 1.26)
PS-adjusted	1727	95/140 (67.9)	1632/2912 (56.0)	66.3 (58.3, 74.2)	56.1 (54.3, 57.9)	10.1 (2.0, 18.3)	1.18 (1.04, 1.34)

Abbreviations: PS - propensity score, EDTR- ED treat and release.

^a Adjusted for race, insurance type, ADI, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score; ^c Limited to NTSV deliveries; ^d Limited to deliveries with a previous cesarean delivery.

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STABLE 3

Risk-Adjusted frequency of neonatal outcomes for self-reported black patients

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
NICU ^f							
Crude	574	18/139 (13.0)	556/2913 (19.1)	12.9 (7.2, 18.4)	19.1 (17.7, 20.5)	-6.2 (-12.0, -0.51)	0.67 (0.43, 1.04)
PS-matched ^b	63	18/138 (13.0)	45/276 (16.3)	13.1 (7.5, 18.7)	16.3 (12.0, 20.6)	-3.2 (-10.2, 3.8)	0.80 (0.49, 1.33)
PS-adjusted	568	18/139 (13.0)	550/2884 (19.1)	12.4 (7.0, 17.8)	19.1 (17.7, 20.5)	-6.7 (-12.3, -1.1)	0.65 (0.42, 1.01)
Unexpected severe complication in term newborns ^d							
Crude	29	1/100 (1.0)	28/2033 (1.4)	1.0 (-0.97, 3.0)	1.4 (0.87, 1.9)	-0.36 (-2.4, 1.7)	0.74 (0.10, 5.39)
PS-matched ^b	3	1/100 (1.0)	2/196 (1.0)	2.1 (-1.8, 5.9)	1.6 (-0.57, 3.8)	0.46 (-4.0, 4.9)	1.29 (0.12, 13.4)
PS-adjusted	29	1/100 (1.0)	28/2014 (1.4)	1.0 (-1.0, 3.1)	1.4 (0.87, 1.9)	-0.34 (-2.4, 1.8)	0.75 (0.10, 5.51)
Unexpected moderate complication in term newborns ^d							
Crude	25	1/100 (1.0)	224/2033 (1.2)	0.95 (-0.90, 2.8)	1.2 (0.71, 1.7)	-0.23 (-2.2, 1.7)	0.80 (0.11, 5.87)
PS-matched ^b	4	1/100 (1.0)	3/196 (1.5)	1.7 (-1.6, 5.1)	2.6 (-0.30, 5.5)	-0.86 (-5.3, 3.6)	0.67 (0.07, 6.27)
PS-adjusted	25	1/100 (1.0)	24/2014 (1.2)	0.90 (-0.87, 2.7)	1.2 (0.72, 1.7)	-0.30 (-2.1, 1.5)	0.75 (0.10, 5.59)
Breastfeeding							
Exclusive							
Crude	584	43/140 (30.7)	541/2941 (18.4)	30.8 (23.3, 38.3)	18.4 (17.0, 19.8)	12.4 (4.8, 20.1)	1.68 (1.30, 2.16)
PS-matched ^b	90	43/139 (30.9)	47/276 (17.0)	30.9 (23.3, 38.6)	17.0 (12.6, 21.4)	13.9 (5.1, 22.7)	1.82 (1.27, 2.60)
PS-adjusted	581	43/140 (30.7)	538/2912 (18.5)	34.8 (25.4, 44.2)	22.4 (20.5, 24.2)	12.5 (2.9, 22.0)	1.56 (1.18, 20.6)
Nonexclusive							
Crude	1498	69/140 (49.3)	1429/2941 (48.6)	49.0 (40.8, 57.3)	48.6 (46.8, 50.4)	0.42 (-0.8, 8.9)	1.01 (0.85, 1.20)
PS-matched ^b	201	69/139 (49.6)	132/276 (47.8)	49.6 (41.3, 57.9)	47.9 (42.0, 53.7)	1.7 (-8.4, 11.9)	1.04 (0.84, 1.27)
PS-adjusted	1482	69/140 (49.3)	1413/2912 (48.5)	47.9 (40.0, 56.2)	48.6 (47.8, 50.4)	-0.72 (-9.2, 7.8)	0.99 (0.83, 1.18)
PTB							
Overall							
Crude	424	16/140 (11.4)	408/2941 (13.9)	11.5 (6.2, 16.7)	13.9 (12.6, 15.1)	-2.4 (-7.8, 3.0)	0.83 (0.52, 1.32)
PS-matched ^b	54	16/139 (11.5)	38/276 (13.8)	11.5 (6.2, 16.8)	13.8 (9.7, 17.8)	-2.3 (-8.9, 4.4)	0.84 (0.48, 1.45)
PS-adjusted	420	16/140 (11.4)	404/2912 (13.9)	10.7 (5.7, 15.7)	13.9 (12.7, 15.2)	-3.2 (-8.4, 2.0)	0.77 (0.48, 1.24)

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(continued)

STABLE 3

Risk-Adjusted frequency of neonatal outcomes for self-reported black patients (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
<i>Spontaneous</i>							
Crude	220	9/140 (6.4)	211/2941 (7.2)	6.4 (2.4, 10.5)	7.2 (6.2, 8.1)	-0.74 (-4.9, 3.4)	0.90 (0.47, 1.71)
PS-matched ^b	25	9/139 (6.5)	16/276 (5.8)	6.4 (2.4, 10.4)	5.8 (3.1, 8.6)	0.57 (-4.3, 5.5)	1.10 (0.50, 2.42)
PS-adjusted	219	9/140 (6.4)	210/2912 (7.2)	6.6 (2.4, 10.7)	7.2 (6.3, 8.1)	-0.64 (-4.9, 3.6)	0.91 (0.48, 1.74)
<i>Indicated</i>							
Crude	204	7/140 (5.0)	197/2941 (6.7)	5.0 (1.4, 8.7)	6.7 (5.8, 7.6)	-1.7 (-5.4, 2.1)	0.75 (0.36, 1.57)
PS-matched ^b	29	7/139 (5.0)	22/276 (8.0)	5.0 (1.4, 8.6)	8.0 (4.8, 11.2)	-3.0 (-7.8, 1.9)	0.63 (0.27, 1.43)
PS-adjusted	201	7/140 (5.0)	194/2912 (6.7)	4.3 (1.1, 7.4)	6.7 (5.8, 7.6)	-2.5 (-5.7, 0.78)	0.63 (0.30, 1.33)
<i>IUGR Diagnosis</i>							
Crude	166	10/140 (7.1)	156/2941 (5.3)	7.2 (2.9, 11.5)	5.3 (4.5, 6.1)	1.9 (-2.5, 6.3)	1.36 (0.73, 2.52)
PS-matched ^b	26	10/139 (7.2)	16/276 (5.8)	7.2 (2.9, 1.4)	5.8 (3.1, 8.6)	1.4 (-3.7, 6.5)	1.23 (0.58, 2.65)
PS-adjusted	166	10/140 (7.1)	156/2941 (5.3)	7.6 (3.1, 12.2)	5.3 (4.5, 6.1)	2.3 (-2.3, 7.0)	1.44 (0.78, 2.67)

^a Adjusted for insurance type, ADL, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score; ^c 160 missing NICU status (n=17,848 for that analysis). 9 missing in matched cohort; ^d Only those deemed eligible by PC06 definitions are included in the denominator. Specifically, deliveries with liveborn, term singletons, ≥ 2500 g, with no congenital malformations/pre-existing fetal conditions nor maternal drug use.

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STABLE 4

Delivery characteristics of liveborn deliveries to White patients at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n=13,014)

Factor	No Doula n (%)	Doula n (%)	p-value ^b
N	12738	276	
<i>Prenatal Characteristics^a</i>			
Ethnicity			0.002
Declined	489 (3.9%)	17 (6.2%)	
Hispanic or Latino	212 (1.7%)	11 (4.0%)	
Not Hispanic or Latino	11972 (94.5%)	247 (89.8%)	
Maternal age	31.1 (5.0)	31.9 (4.9)	0.004
Insurance			0.48
Commercial	9918 (77.9%)	214 (77.5%)	
Medicaid	2605 (20.5%)	54 (19.6%)	
Medicare	61 (0.5%)	2 (0.7%)	
Self-Pay/ Other	154 (1.2%)	6 (2.2%)	
Area Deprivation Index [Mean (SD)]	57.6 (23.5)	58.6 (22.6)	0.51
Nulliparous	3984 (31.3%)	101 (36.6%)	0.060
Gestational age at first visit [Median (IQR)]	64 (56, 76)	63.5 (55, 78)	0.77
Trimester at first visit			
First	11093 (87.1%)	232 (84.1%)	0.20
Second	1066 (8.4%)	33 (12.0%)	
Third	575 (4.5%)	11 (4.0%)	
Number of prenatal visits	12 (10, 13)	12 (10, 14)	0.001
Pregravid weight (lbs)	153 (133, 185)	148 (131, 179)	0.16
Morbidly obese	776 (6.1%)	13 (4.7%)	0.34
Chronic HTN	290 (2.3%)	4 (1.4%)	0.36
Any gestational HTN	2242 (17.6%)	44 (15.9%)	0.47
Prior to 20 weeks ^c	554 (4.3%)	17 (6.2%)	0.15
After 20 weeks	2662 (20.9%)	52 (18.8%)	0.41
Preeclampsia	300 (2.4%)	7 (2.5%)	0.84
Prior to 20 weeks	75 (0.6%)	2 (0.7%)	0.77
After 20 weeks	1084 (8.5%)	21 (7.6%)	0.60
Diabetes T1/T2	120 (0.9%)	4 (1.4%)	0.39
GDM	1093 (8.6%)	23 (8.3%)	0.88
Anxiety	2169 (17.0%)	48 (17.4%)	0.87
Depression	1714 (13.5%)	47 (17.0%)	0.086
Tobacco use	1152 (9.0%)	16 (5.8%)	0.062
Antepartum ED	2664 (20.9%)	68 (24.6%)	0.13
Antepartum admission	885 (6.9%)	23 (8.3%)	0.37
<i>Delivery Characteristics</i>			
C-Section	4182 (32.8%)	90 (32.6%)	0.94
NTSV Cesarean ^d	1215 (26.5%)	41 (29.5%)	0.44

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(continued)

STABLE 4

Delivery characteristics of liveborn deliveries to White patients at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n = 13,014) (continued)

Factor	No Doula n (%)	Doula n (%)	p-value ^b
VBAC ^h	391 (18.1%)	11 (35.5%)	0.013
Maternal delivery weight	156.2 (136, 188.2)	153 (134.6, 182.6)	0.30
Birthweight ^e	3310 (2960, 3630)	3330 (3010, 3720)	0.057
IUGR	367 (2.9%)	11 (4.0%)	0.28
PTB (<37 weeks)	1312 (10.3%)	13 (4.7%)	0.002
EPTB (<34 weeks)	376 (3.0%)	2 (0.7%)	0.029
VEPTB (<28 weeks)	108 (0.8%)	0 (0.0%)	0.12
Indicated PTB	681 (5.3%)	6 (2.2%)	0.020
Spontaneous PTB	631 (5.0%)	7 (2.5%)	0.066
Overall Inductions	5193 (40.8%)	102 (37.0%)	0.20
Obstetric HTN diagnosis	3125 (24.5%)	69 (25.0%)	0.86
Preeclampsia	1085 (8.5%)	22 (8.0%)	0.75
SMM	329 (2.6%)	7 (2.5%)	0.96
NICU at time of delivery	2040 (16.0%)	44 (15.9%)	0.96
Unexpected complication in term newborn ^f	217 (2.2%)	7 (3.1%)	0.38
Moderate	159 (1.6%)	6 (2.6%)	0.23
Severe	131 (1.3%)	4 (1.8%)	0.58
<i>Postpartum follow-up^g</i>			
Office Visit	10584 (83.1%)	248 (89.9%)	0.003
EDTR	1024 (8.0%)	23 (8.3%)	0.86
Postpartum readmission	592 (4.6%)	14 (5.1%)	0.74

SD=standard deviation; IQR=interquartile range; HTN=hypertension; GDM=gestational diabetes; ED=emergency department; NTSV=nulliparous, term, singleton, vertex; VBAC=vaginal birth after cesarean; IUGR=intrauterine growth restriction; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; NICU=neonatal intensive care unit; PC06= Perinatal Care metric 06.

^a Missingness of variables at prenatal visit are filled in with those populated at time of delivery when available; ^b Pearson's chi-squared, Two sample t test, Wilcoxon rank sum as appropriate; ^c Excludes chronic hypertension; ^d Denominator limited to NTSV eligible (n=6007 in no doula; 231 in doula); ^e Birthweight reflective of smallest infant for multiples; ^f Denominator limited to PC06 eligible (n=13260 in no doula; 389 in doula); ^g Within 6 weeks of delivery; ^h Denominator limited to those with previous cesarean delivery (n=3088 in no doula; 64 in doula).

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STABLE 5
Risk-Adjusted frequency of maternal outcomes in self-reported white patients (n = 13014)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
Cesarean Delivery							
Crude	4272	90/276 (32.6)	4182/12738 (32.8)	32.5 (27.0, 38.1)	32.8 (32.0, 33.7)	-0.31 (-5.9, 5.3)	0.99 (0.83, 1.17)
PS-matched ^b	270	90/276 (32.6)	180/550 (32.7)	32.6 (27.1, 38.1)	32.7 (28.8, 36.6)	-0.14 (-6.9, 6.6)	1.0 (0.81, 1.22)
PS-adjusted	4263	90/276 (32.6)	4173/12720 (32.8)	31.7 (26.3, 37.2)	32.8 (32.0, 33.6)	-1.1 (-6.6, 4.4)	0.97 (0.81, 1.15)
NTSV Cesarean Delivery ^c							
Crude	1256	41/139 (29.5)	1215/4580 (26.5)	29.9 (22.3, 37.6)	26.5 (25.2, 27.8)	3.4 (-4.4, 11.1)	1.13 (0.87, 1.46)
PS-matched ^b	100	41/139 (29.5)	59/211 (28.0)	29.4 (21.7, 37.1)	28.1 (219, 34.2)	1.3 (-8.7, 11.3)	1.05 (0.74, 1.48)
PS-adjusted	1254	41/139 (29.5)	1213/4576 (26.5)	29.3 (21.7, 36.8)	26.5 (25.2, 27.8)	2.7 (-4.9, 10.4)	1.10 (0.85, 1.43)
VBAC ^d							
Crude	402	11/31 (35.5)	391/2164 (18.1)	36.4 (19.3, 53.5)	18.1 (16.4, 19.7)	18.4 (1.2, 35.5)	2.02 (1.25, 3.25)
PS-matched ^b	21	11/31 (35.5)	10/81 (12.4)	34.0 (17.6, 50.5)	13.3 (5.7, 20.9)	20.7 (2.5, 39.0)	2.56 (1.20, 5.44)
PS-adjusted	402	11/31 (35.5)	391/2164 (18.1)	35.6 (18.7, 52.5)	18.1 (16.5, 19.7)	17.5 (0.57, 34.5)	1.97 (1.22, 3.19)
Late hypertension							
Crude	2714	52/276 (18.8)	2662/12738 (20.9)	18.4 (13.9, 22.9)	20.9 (20.2, 21.6)	-2.5 (-7.1, 2.1)	0.88 (0.68, 1.13)
PS-matched ^b	169	52/276 (18.8)	117/550 (21.3)	18.8 (14.3, 23.4)	21.2 (17.9, 24.7)	-2.5 (-8.2, 3.2)	0.88 (0.66, 1.18)
PS-adjusted	2711	52/276 (18.8)	2659/12720 (20.9)	18.6 (14.0, 23.2)	20.9 (20.2, 21.6)	-2.3 (-6.9, 2.3)	0.89 (0.69, 1.14)
Late preeclampsia							
Crude	1105	21/276 (7.6)	1084/12738 (8.5)	7.4 (4.4, 10.5)	8.5 (8.0, 9.0)	-1.1 (-4.2, 2.0)	0.87 (0.58, 1.32)
PS-matched ^b	62	21/276 (7.6)	41/550 (7.5)	7.6 (4.5, 10.7)	7.5 (5.3, 9.7)	0.14 (-3.7, 4.0)	1.02 (0.62, 1.69)
PS-adjusted	1101	21/276 (7.6)	1080/12720 (8.5)	7.2 (4.3, 10.2)	8.5 (8.0, 9.0)	-1.3 (-4.3, 1.8)	0.85 (0.56, 1.29)
Postpartum EDTR							
Crude	1047	23/276 (8.3)	1024/12738 (8.0)	8.3 (5.0, 11.5)	8.0 (7.6, 8.5)	0.21 (-3.1, 3.5)	1.03 (0.69, 1.53)
PS-matched ^b	65	23/276 (8.3)	42/550 (7.6)	8.4 (5.1, 11.6)	7.6 (5.4, 9.8)	0.73 (-3.2, 4.7)	1.10 (0.67, 1.78)
PS-adjusted	1044	23/276 (8.3)	1021/12720 (8.0)	8.4 (5.1, 11.7)	8.0 (7.6, 8.5)	0.35 (-3.0, 3.7)	1.04 (0.70, 1.55)
Postpartum Readmission							
Crude	606	14/276 (5.1)	592/12738 (4.7)	5.1 (2.5, 7.7)	4.7 (4.3, 5.0)	0.47 (-2.2, 3.1)	1.10 (0.66, 1.84)
PS-matched ^b	46	14/276 (5.1)	32/550 (5.8)	5.1 (2.5, 7.7)	5.8 (3.9, 7.8)	-0.74 (-4.0, 2.5)	0.87 (0.47, 1.61)

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(continued)

STABLE 5
Risk-Adjusted frequency of maternal outcomes in self-reported white patients (n = 13014) (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
PS-adjusted	604	14/276 (5.1)	590/12720 (4.6)	5.2 (2.5, 7.9)	4.6 (4.3, 5.0)	0.55 (-2.1, 3.2)	1.12 (0.67, 1.88)
<i>Postpartum Office Visit</i>							
Crude	10832	248/276 (89.9)	10584/12738 (83.1)	89.9 (86.4, 93.3)	83.1 (82.5, 83.7)	6.8 (3.3, 10.3)	1.08 (1.04, 1.12)
PS-matched ^b	715	248/276 (89.9)	467/550 (84.9)	89.9 (86.4, 93.3)	84.9 (82.0, 87.8)	5.0 (0.48, 9.5)	1.06 (1.01, 1.11)
PS-adjusted	10817	248/276 (89.9)	10569/12720 (83.1)	89.6 (86.0, 93.3)	83.1 (82.5, 83.8)	6.5 (2.8, 10.2)	1.08 (1.03, 1.12)

Abbreviations: PS - propensity score, EDTR- ED treat and release.

^a Adjusted for race, insurance type, ADI, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score; ^c Limited to NTSV deliveries; ^d Limited to deliveries with a previous cesarean delivery.

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STABLE 6

Risk-Adjusted frequency of neonatal outcomes in self-reported white patients

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
NICU ^f							
Crude	2072	44/276 (15.9)	2028/12634 (16.1)	15.6 (11.4, 19.8)	16.1 (15.4, 16.7)	-0.43 (-4.7, 3.8)	0.97 (0.74, 1.28)
PS-matched ^b	138	44/276 (15.9)	94/547 (17.2)	16.0 (11.7, 20.2)	17.2 (14.1, 20.3)	-1.2 (-6.5, 4.1)	0.93 (0.67, 1.28)
PS-adjusted	2067	44/276 (15.9)	2023/12616 (16.0)	15.5 (11.3, 19.7)	16.1 (15.4, 16.7)	-0.58 (-4.9, 3.7)	0.96 (0.73, 1.27)
Unexpected severe complication in term newborn ^d							
Crude	135	4/229 (1.8)	131/9875 (1.3)	1.7 (0.05, 3.3)	1.3 (1.1, 1.6)	0.36 (-1.3, 2.0)	1.27 (0.47, 3.4)
PS-matched ^b	11	4/229 (1.8)	7/422 (1.7)	1.7 (0.07, 3.3)	1.7 (0.47, 2.9)	-0.02 (-2.0, 2.0)	0.99 (0.30, 3.30)
PS-adjusted	135	4/229 (1.8)	131/9863 (1.3)	1.7 (0.05, 3.4)	1.3 (1.1, 1.6)	0.39 (-1.3, 2.1)	1.29 (0.48, 3.48)
Unexpected moderate complication in term newborn ^d							
Crude	165	6/229 (2.6)	159/9875 (1.6)	2.6 (0.54, 4.6)	1.6 (1.4, 1.9)	0.97 (-1.1, 3.0)	1.60 (0.72, 3.58)
PS-matched ^b	17	6/229 (2.6)	8/422 (1.9)	2.6 (0.55, 4.6)	1.9 (0.6, 3.2)	0.66 (-1.8, 3.1)	1.34 (0.47, 3.83)
PS-adjusted	165	6/229 (2.6)	159/9863	2.5 (0.53, 4.6)	1.6 (1.4, 1.9)	0.93 (-1.1, 3.0)	1.57 (0.70, 3.53)
Breastfeeding							
Exclusive							
Crude	5555	151/276 (54.7)	5404/12738	55.4 (49.7, 61.0)	42.4 (41.6, 43.2)	12.9 (7.2, 18.7)	1.30 (1.18, 1.45)
PS-matched ^b	381	151/276 (54.7)	230/550 (41.8)	54.6 (49.0, 60.3)	41.8 (37.9, 45.8)	12.8 (5.9, 19.7)	1.31 (1.13, 1.50)
PS-adjusted	5552	151/276 (54.7)	5401/12720 (42.5)	60.9 (54.6, 67.3)	49.6 (48.6, 50.6)	11.4 (4.9, 17.8)	1.23 (1.11, 1.37)
Nonexclusive							
Crude	5010	114/276 (41.3)	4896/12738 (38.4)	40.9 (35.1, 46.7)	38.4 (37.6, 39.3)	2.5 (-3.4, 8.3)	1.06 (0.92, 1.23)
PS-matched ^b	313	114/276 (41.3)	199/550 (36.2)	41.4 (35.6, 47.2)	36.2 (32.2, 40.2)	5.2 (-1.9, 12.2)	1.14 (0.96, 1.37)
PS-adjusted	5002	114/276 (41.3)	4888/12720 (38.4)	40.7 (34.9, 46.5)	38.4 (37.6, 39.3)	2.3 (-3.6, 8.2)	1.06 (0.92, 1.22)
PTB							
Overall							
Crude	1325	13/276 (4.7)	1312/12738 (10.3)	4.7 (2.2, 7.2)	10.3 (9.8, 10.8)	-5.6 (-8.2, -3.1)	0.45 (0.27, 0.77)
PS-matched ^b	69	13/276 (4.7)	56/550 (10.2)	4.7 (2.2, 7.2)	10.2 (7.7, 12.7)	-5.5 (-9.0, -1.9)	0.46 (0.26, 0.83)
PS-adjusted	1322	13/276 (4.7)	1309/12720 (10.3)	4.5 (2.1, 7.0)	10.3 (9.8, 10.8)	-5.8 (-8.2, -3.3)	0.44 (0.26, 0.75)

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(continued)

STABLE 6

Risk-Adjusted frequency of neonatal outcomes in self-reported white patients (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
<i>Spontaneous</i>							
Crude	638	7/276 (2.5)	631/12738 (5.0)	2.5 (0.68, 4.4)	5.0 (4.6, 5.3)	-2.4 (-4.3, -0.56)	0.51 (0.24, 1.06)
PS-matched ^b	37	7/276 (2.5)	30/550 (5.5)	2.5 (0.69, 4.4)	5.5 (3.6, 7.3)	-2.9 (-5.6, -0.28)	0.46 (0.21, 1.04)
PS-adjusted	637	7/276 (2.5)	630/12721 (5.0)	2.5 (0.67, 4.4)	5.0 (4.6, 5.3)	-2.4 (-4.3, -0.55)	0.51 (0.24, 1.06)
<i>Indicated</i>							
Crude	687	6/276 (2.2)	681/12738 (5.4)	2.2 (0.45, 3.9)	5.4 (5.0, 5.7)	-3.2 (-4.9, -1.4)	0.40 (0.18, 0.89)
PS-matched ^b	32	6/276 (2.2)	26/ 550 (4.7)	2.2 (0.46, 3.9)	4.7 (3.0, 6.5)	-2.5 (-5.0, -0.08)	0.46 (0.19, 1.11)
PS-adjusted	685	6/276 (2.2)	679/12720 (5.3)	2.0 (0.42, 3.7)	5.4 (5.0, 5.7)	-3.3 (-5.0, -1.6)	0.38 (0.17, 0.85)
<i>IUGR Diagnosis</i>							
Crude	378	11/276 (4.0)	367/12738 (2.9)	3.9 (1.7, 6.1)	2.9 (2.6, 3.2)	1.0 (-1.3, 3.3)	1.35 (0.75, 2.42)
PS-matched ^b	20	11/276 (4.0)	9/550 (1.6)	4.0 (1.7, 6.3)	1.6 (0.58, 2.7)	2.4 (-0.17, 4.9)	2.45 (1.03, 5.81)
PS-adjusted	375	11/276 (4.0)	364/12720 (2.9)	3.9 (1.6, 6.2)	2.9 (2.6, 3.2)	1.0 (-1.3, 3.3)	1.36 (0.75, 2.45)

SD=standard deviation; IQR=interquartile range; HTN=hypertension; GDM=gestational diabetes; ED=emergency department; NTSV=nulliparous, term, singleton, vertex; VBAC=vaginal birth after cesarean; IUGR=intrauterine growth restriction; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; NICU=neonatal intensive care unit; PC06=Perinatal Core metric 06.

^a Adjusted for race, insurance type, ADI, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score; ^c 104 missing NICU status (n=12,910 for that analysis). 3 missing in matched cohort; ^d Only those deemed eligible by PC06 definitions are included in the denominator. Specifically, deliveries with liveborn, term singletons, ≥ 2500 g, with no congenital malformations/pre-existing fetal conditions nor maternal drug use.

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Results stratified by insurance

STABLE 7

Delivery characteristics of liveborn deliveries to commercially insured patients at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n = 12398)

Factor	No Doula n (%)	Doula n (%)	p-value ^b
N	12091	307	
<i>Prenatal Characteristics^a</i>			
Self-reported race			<0.001
White	9918 (82.0%)	214 (69.7%)	
Black	946 (7.8%)	40 (13.0%)	
Other	1170 (9.7%)	50 (16.3%)	
Unknown	57 (0.5%)	3 (1.0%)	
Ethnicity			0.10
Declined	609 (5.1%)	24 (7.9%)	
Hispanic or Latino	213 (1.8%)	8 (2.6%)	
Not Hispanic or Latino	11138 (93.1%)	271 (89.4%)	
Maternal age	31.6 (4.7)	32.1 (4.6)	0.061
Area Deprivation Index [Mean (SD)]	54.9 (23.4)	57.544 (23.6)	0.050
Nulliparous	4122 (34.1%)	117 (38.1%)	0.14
Gestational age at first visit [Median (IQR)]	63 (56, 73)	62 (55, 72)	0.27
Trimester at first visit			
First	10871 (89.9%)	271 (88.3%)	0.76
Second	804 (6.6%)	25 (8.1%)	
Third	413 (3.4%)	11 (3.6%)	
Number of prenatal visits	12 (10, 14)	12 (11, 14)	0.004
Pregravid weight (lbs)	151 (132, 182)	145 (130, 168)	0.011
Morbidly obese	624 (5.2%)	7 (2.3%)	0.023
Chronic HTN	262 (2.2%)	6 (2.0%)	0.80
Any gestational HTN	2004 (16.6%)	44 (14.3%)	0.30
Prior to 20 weeks ^c	505 (4.2%)	18 (5.9%)	0.15
After 20 weeks	2423 (20.0%)	51 (16.6%)	0.14
Preeclampsia	260 (2.2%)	6 (2.0%)	0.81
Prior to 20 weeks	72 (0.6%)	2 (0.7%)	0.90
After 20 weeks	989 (8.2%)	25 (8.1%)	0.98
Diabetes T1/T2	96 (0.8%)	4 (1.3%)	0.32
GDM	1109 (9.2%)	29 (9.4%)	0.87
Anxiety	1682 (13.9%)	45 (14.7%)	0.71
Depression	1206 (10.0%)	42 (13.7%)	0.033
Tobacco use	444 (3.7%)	7 (2.3%)	0.20
Antepartum ED	2349 (19.4%)	78 (25.4%)	0.009
Antepartum admission	701 (5.8%)	20 (6.5%)	0.60

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(continued)

STABLE 7

Delivery characteristics of liveborn deliveries to commercially insured patients at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n = 12398) (continued)

Factor	No Doula n (%)	Doula n (%)	p-value ^b
<i>Delivery Characteristics</i>			
C-Section	4034 (33.4%)	101 (32.9%)	0.86
NTSV Cesarean ^d	1315 (27.7%)	54 (31.0%)	0.34
VBAC	368 (18.8%)	11 (39.3%)	0.006
Maternal delivery weight	154 (134.2, 185)	147 (131, 179)	0.012
Birthweight ^e	3310 (2980, 3630)	3275 (2980, 3670)	0.99
IUGR	293 (2.4%)	13 (4.2%)	0.043
PTB (<37 weeks)	1117 (9.2%)	17 (5.5%)	0.026
EPTB (<34 weeks)	312 (2.6%)	2 (0.7%)	0.034
VEPTB (<28 weeks)	104 (0.9%)	0 (0.0%)	0.10
Indicated PTB	577 (4.8%)	9 (2.9%)	0.13
Spontaneous PTB	540 (4.5%)	8 (2.6%)	0.12
Overall Inductions	4834 (40.0%)	113 (36.8%)	0.26
Obstetric HTN diagnosis	2848 (23.6%)	70 (22.8%)	0.76
Preeclampsia	992 (8.2%)	26 (8.5%)	0.87
SMM	294 (2.4%)	10 (3.3%)	0.36
NICU at time of delivery	1750 (14.6%)	40 (13.0%)	0.44
Unexpected complication in term newborns ^f	191 (2.0%)	5 (2.0%)	0.99
Moderate	145 (1.5%)	4 (1.6%)	0.92
Severe	114 (1.2%)	4 (1.6%)	0.57
<i>Postpartum follow-up^g</i>			
Office Visit	10467 (86.6%)	280 (91.2%)	0.018
EDTR	971 (8.0%)	29 (9.4%)	0.37
Postpartum readmission	553 (4.6%)	15 (4.9%)	0.80

SD=standard deviation; IQR=interquartile range; HTN=hypertension; GDM=gestational diabetes; ED=emergency department; NTSV=nulliparous, term, singleton, vertex; VBAC=vaginal birth after cesarean; IUGR=intrauterine growth restriction; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; NICU=neonatal intensive care unit; PC06=Perinatal Core metric 06.

^a Missingness of variables at prenatal visit are filled in with those populated at time of delivery when available; ^b Pearson's chi-squared, Two sample t test, Wilcoxon rank sum as appropriate;

^c Excludes chronic hypertension; ^d Denominator limited to NTSV eligible (n=4,742 in no doula; 174 in doula); ^e Birthweight reflective of smallest infant for multiples; ^f Denominator limited to PC06 eligible (n=9,747 in no doula; 256 in doula); ^g Within 6 weeks of delivery.

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STABLE 8

Risk-Adjusted frequency of maternal outcomes in commercially insured patients (N = 12398)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
Cesarean Delivery							
Crude	4135	101/307 (32.9)	4034/12091 (33.4)	32.5 (27.3, 37.7)	33.4 (32.5, 34.2)	-0.87 (-6.2, 4.4)	0.97 (0.83, 1.15)
PS-matched ^b	323	100/306 (32.7)	223/610 (36.6)	32.8 (27.5, 38.1)	36.5 (32.7, 40.3)	-3.7 (-10.2, 2.8)	0.90 (0.74, 1.09)
PS-adjusted	4134	101/307 (32.9)	4033/12089 (33.4)	32.0 (26.9, 37.2)	33.4 (32.5, 34.2)	-1.3 (-0.66, 3.9)	0.96 (0.81, 1.13)
NTSV Cesarean Delivery ^c							
Crude	1369	54/174 (31.0)	1315/4742 (27.7)	31.5 (24.5, 38.4)	27.7 (26.4, 29.0)	3.8 (-3.3, 10.8)	1.14 (0.91, 1.42)
PS-matched ^b	141	54/174 (31.0)	87/253 (34.4)	30.5 (23.5, 37.4)	34.8 (28.9, 40.8)	-4.4 (-13.7, 4.9)	0.87 (0.65, 1.17)
PS-adjusted	1369	54/174 (31.0)	1315/4742 (27.7)	30.4 (23.6, 37.2)	27.8 (26.5, 29.0)	2.7 (-4.3, 9.6)	1.10 (0.87, 1.38)
VBAC ^d							
Crude	379	11/28 (39.3)	368/1953 (18.8)	39.6 (21.4, 57.7)	18.8 (17.1, 20.6)	20.7 (2.4, 39.0)	2.10 (1.31, 3.36)
PS-matched ^b	24	11/28 (39.3)	13/91 (14.3)	40.8 (22.1, 59.4)	14.6 (7.2, 21.9)	26.2 (6.1, 46.3)	2.80 (1.14, 5.55)
PS-adjusted ^d	379	11/28 (39.3)	368/1952 (18.9)	39.7 (21.4, 57.9)	18.9 (17.1, 20.6)	20.8 (2.5, 39.2)	2.10 (1.32, 3.36)
Hypertension after 20 weeks							
Crude	2474	51/307 (16.6)	2423/12091 (20.0)	16.8 (12.6, 21.0)	20.0 (19.3, 20.7)	-3.3 (-7.5, 0.98)	0.84 (0.65, 1.08)
PS-matched ^b	159	51/306 (16.7)	108/610 (17.7)	16.7 (12.6, 20.9)	17.7 (14.7, 20.6)	-0.95 (-6.0, 4.1)	0.95 (0.70, 1.28)
PS-adjusted	2474	51/307 (16.6)	2423/12089 (20.0)	17.4 (13.1, 21.7)	20.0 (19.3, 20.7)	-2.6 (-7.0, 1.8)	0.87 (0.68, 1.12)
Preeclampsia after 20 weeks							
Crude	1014	25/307 (8.1)	989/12091 (8.2)	8.0 (5.0, 11.0)	8.2 (7.7, 8.7)	-0.2 (-3.2, 2.8)	0.98 (0.67, 1.43)
PS-matched ^b	73	24/306 (7.8)	49/610 (8.0)	7.9 (4.9, 10.9)	8.0 (5.9, 10.1)	-0.08 (-3.8, 3.6)	0.99 (0.62, 1.58)
PS-adjusted	1013	25/307 (8.1)	988/12089 (8.2)	7.7 (4.8, 10.6)	8.2 (7.7, 8.7)	-0.48 (-3.4, 2.5)	0.94 (0.6, 1.38)
Postpartum EDTR							
Crude	1000	29/307 (9.5)	971/12091 (8.0)	9.4 (6.1, 12.6)	8.0 (7.6, 8.5)	1.3 (-2.0, 4.6)	1.16 (0.82, 1.66)
PS-matched ^b	95	29/306 (9.5)	66/610 (10.8)	9.6 (6.3, 12.9)	10.8 (8.3, 13.2)	-1.2 (-5.3, 2.9)	0.89 (0.59, 1.35)
PS-adjusted	1000	29/307 (9.5)	971/12089 (8.0)	9.1 (6.0, 12.3)	8.0 (7.6, 8.5)	1.1 (-2.1, 4.3)	1.14 (0.80, 1.62)
Postpartum Readmission							
Crude	568	15/307 (4.9)	553/12091 (4.6)	4.9 (2.5, 7.3)	4.6 (4.2, 5.0)	0.32 (-2.1, 2.8)	1.07 (0.65, 1.76)
PS-matched ^b	42	15/306 (4.9)	27/610 (4.4)	4.8 (2.4, 7.1)	4.5 (2.9, 6.2)	0.25 (-2.6, 3.1)	1.06 (0.57, 1.95)

Lemon. Quantifying the association of doula care with maternal and neonatal outcomes. Am J Obstet Gynecol 2025.

(continued)

STABLE 8
Risk-Adjusted frequency of maternal outcomes in commercially insured patients (N = 12398) (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
PS-adjusted	568	15/307 (4.9)	553/12089 (4.6)	4.8 (2.4, 7.2)	4.6 (4.2, 5.0)	0.25 (-2.2, 2.7)	1.05 (0.64, 1.74)
<i>Postpartum Office Visit</i>							
Crude	10747	280/307 (91.2)	10467/12091 (86.6)	91.7 (88.7, 94.7)	86.6 (86.0, 87.2)	5.1 (2.1, 8.2)	1.06 (1.02, 1.10)
PS-matched ^b	810	279/306 (91.2)	531/610 (87.1)	91.3 (88.2, 94.5)	87.0 (84.3, 89.6)	4.4 (0.25, 8.5)	1.00 (1.00, 1.10)
PS-adjusted	10745	280/307 (91.2)	10465/12089 (86.6)	91.5 (88.4, 94.6)	86.6 (86.0, 87.2)	5.0 (1.8, 8.1)	1.06 (1.02, 1.09)

Abbreviations: PS - propensity score, EDTR- ED treat and release.

^a Adjusted for race, insurance type, ADI, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score in a cohort of only commercially insured; ^c Limited to NTSV deliveries; ^d Limited to deliveries with a previous cesarean delivery.

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STABLE 9

Risk-Adjusted frequency of neonatal outcomes in commercially insured patients

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
NICU ^c							
Crude	1790	40/307 (13.0)	1750/11985 (14.6)	12.8 (9.1, 16.4)	14.6 (14.0, 15.2)	-1.9 (-5.6, 1.9)	0.87 (0.65, 1.17)
PS-matched ^b	138	39/306 (12.8)	99/603 (16.4)	12.8 (9.0, 16.5)	16.4 (13.4, 19.3)	-3.6 (-8.4, 1.2)	0.78 (0.55, 1.10)
PS-adjusted	1789	40/307 (13.0)	1749/11983 (14.6)	12.7 (9.0, 16.4)	14.6 (14.0, 15.2)	-1.9 (-5.7, 1.8)	0.87 (0.65, 1.17)
Unexpected severe complication in term newborns ^d							
Crude	118	4/256 (1.6)	114/9747 (1.2)	1.5 (0.04, 3.0)	1.2 (0.96, 1.4)	0.37 (-1.1, 1.9)	1.31 (0.49, 3.54)
PS-matched ^b	7	4/256 (1.6)	3/487 (0.62)	1.5 (0.04, 2.9)	0.64 (-0.08, 1.4)	0.84 (-0.77, 2.4)	2.32 (0.52, 10.3)
PS-adjusted	118	4/256 (1.6)	114/9746 (1.2)	1.6 (0.04, 3.1)	1.2 (0.96, 1.4)	0.40 (-1.1, 2.0)	1.35 (0.50, 3.63)
Unexpected moderate complication in term newborns ^d							
Crude	149	4/256 (1.6)	145/9747 (1.5)	1.6 (0.04, 3.1)	1.5 (1.3, 1.7)	0.08 (-1.5, 1.6)	1.05 (0.39, 2.8)
PS-matched ^b	10	4/256 (1.6)	6/487 (1.2)	1.5 (0.04, 3.0)	1.2 (0.26, 2.2)	0.294 (-1.5, 2.1)	1.23 (0.35, 4.34)
PS-adjusted	149	4/256 (1.6)	145/9746 (1.5)	1.6 (0.04, 3.1)	1.5 (1.3, 1.7)	0.10 (-1.5, 1.7)	1.07 (0.40, 2.87)
Breastfeeding							
Exclusive							
Crude	5532	156/307 (50.8)	5376/12091 (44.5)	53.2 (47.8, 58.7)	44.4 (43.5, 45.3)	8.8 (3.3, 14.4)	1.20 (1.08, 1.33)
PS-matched ^b	450	156/306 (51.0)	294/610 (48.2)	51.2 (45.7, 56.7)	48.1 (44.2, 52.0)	3.1 (-3.6, 9.9)	1.07 (0.93, 1.22)
PS-adjusted	5532	156/307 (50.8)	5376/12089 (44.5)	56.3 (50.3, 62.4)	50.2 (49.2, 51.1)	6.1 (0.01, 12.3)	1.12 (1.01, 1.25)
Nonexclusive							
Crude	5106	140/307 (45.6)	4966/12091 (41.1)	43.4 (37.9, 48.8)	41.1 (40.3, 42.0)	2.2 (-3.3, 7.8)	1.05 (0.93, 1.20)
PS-matched ^b	379	139/306 (45.4)	240/610 (39.3)	45.2 (39.7, 50.7)	39.5 (35.6, 43.3)	5.7 (-1.0, 12.5)	1.14 (0.98, 1.34)
PS-adjusted	5104	140/307 (45.6)	4964/12089 (41.1)	42.7 (37.2, 48.2)	41.1 (40.3, 42.0)	1.6 (-4.0, 7.2)	1.04 (0.91, 1.18)
PTB							
Overall							
Crude	1134	17/307 (5.5)	1117/12091 (9.2)	5.4 (2.9, 7.9)	9.2 (8.7, 9.8)	-3.9 (-6.4, -1.3)	0.58 (0.67, 0.93)
PS-matched ^b	72	16/306 (5.2)	56/610 (9.2)	5.2 (2.7, 7.7)	9.2 (6.9, 11.5)	-4.0 (-7.4, -0.62)	0.56 (0.33, 0.97)
PS-adjusted	1133	17/307 (5.5)	1116/12089 (9.2)	5.3 (2.8, 7.7)	9.2 (8.7, 9.8)	-4.0 (-6.5, -1.5)	0.57 (0.36, 0.91)

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STABLE 9
Risk-Adjusted frequency of neonatal outcomes in commercially insured patients (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
<i>Spontaneous</i>							
Crude	548	8/307 (2.6)	540/12091 (4.5)	2.5 (0.79, 4.3)	4.5 (4.1, 4.8)	-2.0 (-3.7, -0.18)	0.56 (0.28, 1.12)
PS-matched ^b	33	8/306 (2.6)	25/610 (4.1)	2.6 (0.83, 4.4)	4.1 (2.5, 5.7)	-1.5 (-3.8, 0.93)	0.64 (0.29, 1.41)
PS-adjusted	548	8/307 (2.6)	540/12089 (4.5)	2.5 (0.80, 4.3)	4.5 (4.1, 4.8)	-1.9 (-3.7, -0.15)	0.57 (0.28, 1.13)
<i>Indicated</i>							
Crude	586	9/307 (2.9)	577/12091 (4.8)	2.9 (1.0, 4.7)	4.8 (4.4, 5.2)	-1.9 (-3.8, -0.02)	0.60 (0.31, 1.15)
PS-matched ^b	39	8/306 (2.6)	31/610 (5.1)	2.6 (0.81, 4.3)	5.1 (3.4, 6.9)	-2.6 (-5.1, -0.07)	0.50 (0.23, 1.08)
PS-adjusted	585	9/307 (2.9)	576/12089 (4.8)	2.7 (0.97, 4.5)	4.8 (4.4, 5.2)	-2.0 (-3.9, -0.227)	0.57 (0.30, 1.11)
<i>IUGR Diagnosis</i>							
Crude	306	13/307 (4.2)	293/12091 (2.4)	3.9 (1.8, 6.0)	2.4 (2.2, 2.7)	1.5 (-0.61, 3.6)	1.62 (0.94, 2.80)
PS-matched ^b	32	13/306 (4.3)	19/610 (3.1)	4.2 (2.0, 6.4)	3.2 (1.8, 4.5)	1.0 (-1.6, 3.7)	1.33 (0.66, 2.65)
PS-adjusted	306	13/307 (4.2)	293/12089 (2.4)	4.0 (1.8, 6.1)	2.4 (2.2, 2.7)	1.5 (-0.61, 3.7)	1.63 (0.94, 2.83)

^a Adjusted for race, insurance type, ADI, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score in a cohort of only commercially insured; ^c 106 missing NICU status (n=12,292 for that analysis). 7 missing in matched cohort; ^d Only those deemed eligible by PC06 definitions are included in the denominator. Specifically, deliveries with liveborn, term singletons, ≥2500 g, with no congenital malformations/pre-existing fetal conditions nor maternal drug use.

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STABLE 10

Delivery characteristics of liveborn deliveries to publicly insured patients at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n = 5238)

Factor	No Doula n (%)	Doula n (%)	p-value ^b
N	5066	172	
<i>Prenatal Characteristics^a</i>			
Self-reported race			<0.001
White	2666 (52.6%)	56 (32.6%)	
Black	1982 (39.1%)	99 (57.6%)	
Other	399 (7.9%)	15 (8.7%)	
Unknown	19 (0.4%)	2 (1.2%)	
Ethnicity			0.76
Declined	290 (5.8%)	12 (7.1%)	
Hispanic or Latino	115 (2.3%)	4 (2.4%)	
Not Hispanic or Latino	4621 (91.9%)	153 (90.5%)	
Maternal age	28.2 (5.8)	29.0 (5.9)	0.066
Insurance			0.75
Medicaid	4960 (97.9%)	169 (98.3%)	
Medicare	106 (2.1%)	3 (1.7%)	
Area Deprivation Index [Mean (SD)]	77.9 (19.7)	77.7 (20.6)	0.90
Nulliparous	1169 (23.1%)	45 (26.2%)	0.35
Gestational age at first visit [Median (IQR)]	69 (56, 104)	67 (53, 94.5)	0.099
Trimester at first visit			
First	3675 (72.5%)	132 (76.7%)	0.68
Second	947 (18.7%)	27 (15.7%)	
Third	443 (8.7%)	13 (7.6%)	
Number of prenatal visits	10 (7, 13)	11 (9, 15)	<0.001
Pregravid weight (lbs)	160 (133, 198)	165 (135, 199)	0.41
Morbidly obese	471 (9.3%)	17 (9.9%)	0.79
Chronic HTN	176 (3.5%)	5 (2.9%)	0.69
Any gestational HTN	879 (17.4%)	34 (19.8%)	0.41
Prior to 20 weeks ^c	256 (5.1%)	14 (8.1%)	0.072
After 20 weeks	1020 (20.1%)	31 (18.0%)	0.50
Preeclampsia	123 (2.4%)	6 (3.5%)	0.38
Prior to 20 weeks	30 (0.6%)	3 (1.7%)	0.060
After 20 weeks	497 (9.8%)	17 (9.9%)	0.97
Diabetes T1/T2	81 (1.6%)	1 (0.6%)	0.29
GDM	435 (8.6%)	18 (10.5%)	0.39
Anxiety	790 (15.6%)	21 (12.2%)	0.23
Depression	1007 (19.9%)	32 (18.6%)	0.68
Tobacco use	1228 (24.2%)	29 (16.9%)	0.026
Antepartum ED	2207 (43.6%)	99 (57.6%)	<0.001
Antepartum admission	620 (12.2%)	30 (17.4%)	0.042

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(continued)

STABLE 10

Delivery characteristics of liveborn deliveries to publicly insured patients at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n = 5238) (continued)

Factor	No Doula n (%)	Doula n (%)	p-value ^b
<i>Delivery Characteristics</i>			
C-Section	1710 (33.8%)	54 (31.4%)	0.52
NTSV Cesarean ^d	324 (73.4%)	38 (71.7%)	0.79
VBAC	201 (18.4%)	10 (28.6%)	0.128
Maternal delivery weight	164 (137, 202)	173 (138, 202.6)	0.38
Birthweight ^e	3130 (2760, 3480)	3190 (2880, 3500)	0.22
IUGR	282 (5.6%)	10 (5.8%)	0.89
PTB (<37 weeks)	728 (14.4%)	18 (10.5%)	0.15
EPTB (<34 weeks)	260 (5.1%)	4 (2.3%)	0.098
VEPTB (<28 weeks)	90 (1.8%)	1 (0.6%)	0.24
Indicated PTB	364 (7.2%)	7 (4.1%)	0.12
Spontaneous PTB	364 (7.2%)	11 (6.4%)	0.69
Overall Inductions	1984 (39.2%)	68 (39.5%)	0.92
Obstetric HTN diagnosis	1308 (25.8%)	46 (26.7%)	0.79
Preeclampsia	501 (9.9%)	20 (11.6%)	0.45
SMM	199 (3.9%)	5 (2.9%)	0.50
NICU at time of delivery	1026 (20.4%)	27 (15.9%)	0.15
Unexpected complication in term newborn ^f	95 (2.8%)	4 (3.1%)	0.84
Moderate	59 (1.8%)	3 (2.3%)	0.62
Severe	60 (1.8%)	1 (0.8%)	0.40
<i>Postpartum follow-up^g</i>			
Office Visit	2978 (58.8%)	118 (68.6%)	0.010
EDTR	543 (10.7%)	23 (13.4%)	0.27
Postpartum readmission	314 (6.2%)	13 (7.6%)	0.47

SD=standard deviation; IQR=interquartile range; HTN=hypertension; GDM=gestational diabetes; ED=emergency department; NTSV=nulliparous, term, singleton, vertex; VBAC=vaginal birth after cesarean; IUGR=intrauterine growth restriction; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; NICU=neonatal intensive care unit; PC06= Perinatal Core metric 06.

^a Missingness of variables at prenatal visit are filled in with those populated at time of delivery when available; ^b Pearson's chi-squared, Two sample t test, Wilcoxon rank sum as appropriate;

^c Excludes chronic hypertension; ^d Denominator limited to NTSV eligible (n=6029 in no doula; 232 in doula); ^e Birthweight reflective of smallest infant for multiples; ^f Denominator limited to PC06 eligible (n=13317 in no doula; 391 in doula); ^g Within 6 weeks of delivery.

Lemon. Quantifying the association of doula care with maternal and neonatal outcomes. *Am J Obstet Gynecol* 2025.

STABLE 11
Risk-Adjusted frequency of maternal outcomes in publicly insured patients (n = 5238)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
Cesarean Delivery							
Crude	1764	54/172 (31.4)	1710/5066 (33.8)	31.3 (24.3, 38.2)	33.8 (32.5, 35.1)	-2.5 (-9.6, 4.5)	0.93 (0.74, 1.16)
PS-matched ^b	189	54/172 (31.4)	135/343 (39.4)	31.6 (24.7, 38.6)	39.2 (34.1, 44.4)	-7.6 (-16.3, 1.0)	0.81 (0.62, 1.04)
PS-adjusted	1740	54/172 (31.4)	1686/4997	29.9 (23.2, 36.7)	33.8 (32.5, 35.1)	-3.9 (-10.8, 3.0)	0.89 (0.70, 1.11)
NTSV Cesarean Delivery ^c							
Crude	339	15/53 (28.3)	324/1216 (26.6)	28.0 (15.9, 40.0)	26.7 (24.2, 29.1)	1.3 (-11.0, 13.6)	1.05 (0.67, 1.63)
PS-matched ^b	41	15/53 (28.3)	26/84 (31.0)	28.2 (16.1, 40.3)	31.0 (21.2, 40.9)	-2.8 (-18.6, 12.9)	0.91 (0.53, 1.56)
PS-adjusted	337	15/53 (28.3)	322/1203 (26.8)	26.0 (14.6, 37.5)	26.9 (24.4, 29.4)	-0.83 (-12.6, 10.9)	0.97 (0.62, 1.52)
VBAC ^d							
Crude	211	10/35 (28.6)	201/1093 (18.4)	29.6 (14.3, 44.9)	18.4 (16.1, 20.7)	11.2 (-4.3, 26.7)	1.61 (0.95, 2.75)
PS-matched ^b	20	10/35 (28.6)	10/67 (14.9)	27.9 (13.1, 42.7)	15.2 (6.6, 23.8)	12.7 (-4.6, 30.0)	1.84 (0.84, 4.03)
PS-adjusted	210	10/35 (28.6)	200/1078 (18.6)	28.0 (13.1, 42.8)	18.6 (16.3, 20.9)	9.4 (-5.7, 24.4)	1.50 (0.87, 2.60)
Late hypertension							
Crude	1051	31/172 (18.0)	1020/5066 (20.1)	18.3 (12.5, 24.1)	20.1 (19.0, 21.2)	-1.8 (-7.7, 4.1)	0.91 (0.66, 1.25)
PS-matched ^b	106	31/172 (18.0)	75/343	18.2 (12.4, 23.9)	21.8 (17.5, 26.1)	-3.6 (-10.8, 3.6)	0.83 (0.57, 1.21)
PS-adjusted	1039	31/172 (18.0)	1008/4997 (20.2)	17.9 (12.2, 23.7)	20.2 (19.1, 21.3)	-2.3 (-8.1, 3.6)	0.89 (0.64, 1.23)
Late preeclampsia							
Crude	514	17/172 (9.9)	497/5066 (9.8)	9.9 (5.4,14.3)	9.8 ((9.0, 10.6)	0.05 (-4.5, 4.6)	1.01 (0.64, 1.59)
PS-matched ^b	51	17/171 (9.9)	34/343 (9.9)	10.0 (5.5, 14.5)	9.8 (6.7, 13.0)	0.20 (-5.3, 5.7)	1.02 (0.59, 1.77)
PS-adjusted	505	17/172 (9.9)	488/4997 (9.8)	9.2 (5.0, 13.4)	9.8 (9.0, 10.6)	-0.61 (-4.9, 3.7)	0.94 (0.59, 1.49)
Postpartum EDTR							
Crude	566	23/172 (13.4)	543/5066 (10.7)	12.9 (8.0, 17.8)	10.7 (9.9, 11.6)	2.2 (-2.8, 7.2)	1.20 (0.80, 1.77)
PS-matched ^b	60	23/172 (13.4)	37/343 (10.8)	13.5 (8.4, 18.6)	10.8 (7.5, 14.0)	2.7 (-3.4, 8.8)	1.25 (0.77, 2.03)
PS-adjusted	556	23/172 (13.4)	533/4997 (10.7)	12.9 (7.9, 17.8)	10.7 (9.8, 11.5)	2.2 (-2.8, 7.2)	1.21 (0.81, 1.79)
Postpartum Readmission							
Crude	327	13/172 (7.6)	314/5066 (6.2)	7.3 (3.5, 11.2)	6.2 (5.5, 6.9)	1.1 (-2.8, 5.0)	1.18 (0.69, 2.02)
PS-matched ^b	29	13/172 (7.6)	16/343 (4.7)	7.6 (3.7, 11.6)	4.6 (2.4, 6.9)	3.0 (-1.6, 7.6)	1.64 (0.81, 3.34)

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(continued)

STABLE 11

Risk-Adjusted frequency of maternal outcomes in publicly insured patients (n = 5238) (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
PS-adjusted	320	13/172 (7.6)	307/4997 (6.1)	7.3 (3.4, 11.1)	6.2 (5.5, 6.8)	1.1 (-2.8, 5.0)	1.18 (0.69, 2.02)
<i>Postpartum Office Visit</i>							
Crude	3096	118/172 (68.6)	2978/5066 (58.8)	68.9 (62.1, 75.7)	58.8 (57.4, 60.1)	10.1 (3.2, 17.0)	1.17 (1.06, 1.30)
PS-matched ^b	313	118/172 (68.6)	195 /343 (56.9)	69.0 (62.3, 75.7)	56.7 (51.6, 61.7)	12.4 (3.9, 20.8)	1.22 (1.07, 1.39)
PS-adjusted	3066	118/172 (68.6)	2948/4997 (59.0)	69.4 (62.6, 76.3)	59.0 (57.6, 60.3)	10.5 (3.5, 17.5)	1.18 (1.06, 1.30)

Abbreviations: PS - propensity score, EDTR- ED treat and release.

^a Adjusted for race, insurance type, ADI, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score; ^c Limited to NTSV deliveries; ^d Limited to deliveries with a previous cesarean delivery.

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STABLE 12
Risk-Adjusted frequency of neonatal outcomes in publicly insured patients

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
NICU ^c							
Crude	1053	27/170 (15.9)	1026/5024 (20.4)	16.5 (10.8, 22.1)	20.4 (19.3, 21.5)	-3.9 (-9.7, 1.8)	0.81 (0.57, 1.14)
PS-matched ^b	109	27/170 (15.9)	82/341 (24.1)	15.9 (10.5, 21.4)	24.0 (19.6, 28.5)	-8.1 (-15.2, -10.5)	0.66 (0.45, 0.98)
PS-adjusted	1036	27/170 (15.9)	1009/4956 (20.4)	16.4 (10.7, 22.1)	20.3 (19.2, 21.5)	-3.9 (-9.7, 1.8)	0.81 (0.57, 1.14)
Unexpected severe complication in term newborn ^d							
Crude	61	1/128 (0.78)	60/3363 (1.8)	0.79 (-0.75, 2.3)	1.8 (1.3, 2.2)	-0.99 (-2.6, 0.61)	0.44 (0.06, 3.17)
PS-matched ^b	6	1/128 (0.78)	5/227 (2.2)	0.72 (-0.69, 2.1)	2.3 (0.35, 4.2)	-1.6 (-4.0, 0.84)	0.31 (0.04, 2.68)
PS-adjusted	60	1/128 (0.78)	59/3326 (1.8)	0.83 (-0.80, 2.5)	1.8 (1.3, 2.2)	-0.95 (-2.6, 0.75)	0.47 (0.07, 3.36)
Unexpected severe complication in term newborn ^d							
Crude	62	3/128 (2.3)	59/3363 (1.8)	2.3 (-0.28, 4.9)	1.8 (1.3, 2.2)	0.56 (-2.1, 3.2)	1.32 (0.42, 4.16)
PS-matched ^b	8	3/128 (2.3)	5/227 (2.2)	2.2 (-0.25, 4.7)	2.3 (0.33, 4.2)	-0.02 (-3.2, 3.1)	0.99 (0.24, 4.05)
PS-adjusted	61	3/128 (2.3)	58/3326 (1.7)	2.4 (-0.30, 5.2)	1.7 (1.3, 2.2)	0.69 (-2.1, 3.5)	1.40 (0.44, 4.42)
Breastfeeding							
Exclusive							
Crude	1019	56/172 (32.6)	963/5066 (19.0)	33.9 (26.8, 40.9)	19.0 (17.9, 20.1)	14.9 (7.8, 22.0)	1.79 (1.44, 2.22)
PS-matched ^b	125	56/172 (32.6)	69/343 (20.1)	32.6 (25.7, 39.6)	20.1 (15.9, 24.4)	12.6 (4.5, 20.7)	1.63 (1.21, 2.19)
PS-adjusted	1014	56/172 (32.6)	958/4991 (19.2)	41.9 (33.3, 50.5)	24.1 (22.7, 25.6)	17.8 (9.0, 26.5)	1.74 (1.40, 2.15)
Nonexclusive							
Crude	2364	87/172 (50.6)	2277/5066 (45.0)	48.9 (41.5, 56.3)	45.0 (43.6, 46.4)	3.9 (-3.7, 11.4)	1.09 (0.93, 1.27)
PS-matched ^b	236	87/172 (50.6)	149/343 (43.4)	50.5 (42.1, 58.0)	43.5 (38.3, 48.7)	7.1 (-2.0, 16.1)	1.16 (0.96, 1.41)
PS-adjusted	2329	87/172 (50.6)	2242/4997 (44.9)	47.8 (40.3, 55.2)	45.0 (43.6, 46.3)	2.8 (-4.8, 10.4)	1.06 (0.91, 1.25)
PTB							
Overall							
Crude	746	18/172 (10.5)	728/5066 (14.4)	10.7 (6.1, 15.4)	14.5 (13.4, 15.3)	-3.6 (-8.4, 1.2)	0.75 (0.48, 1.16)
PS-matched ^b	79	18/172 (10.5)	61/343 (17.8)	10.5 (5.9, 15.2)	17.7 (13.7, 21.8)	-7.2 (-13.3, -1.1)	0.59 (0.6, 0.97)
PS-adjusted	733	18/172 (10.5)	715/4997 (14.3)	10.4 (5.9, 15.0)	14.3 (13.3, 15.3)	-3.9 (-8.6, 0.79)	0.73 (0.47, 1.14)

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(continued)

STABLE 12

Risk-Adjusted frequency of neonatal outcomes in publicly insured patients (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
<i>Spontaneous</i>							
Crude	375	11/172 (6.4)	364/5066 (7.2)	6.6 (2.9, 10.4)	7.2 (6.5, 7.9)	-0.56 (-4.4, 3.3)	0.92 (0.52, 1.65)
PS-matched ^b	40	11/172 (6.4)	29/343 (8.5)	6.5 (2.8, 10.1)	8.4 (5.5, 11.3)	-2.0 (-6.7, 2.7)	0.77 (0.39, 1.49)
PS-adjusted	366	11/172 (6.4)	355/4997 (7.1)	6.6 (2.8, 10.4)	7.1 (6.4, 7.8)	-0.47 (-4.3, 3.4)	0.93 (0.52, 1.67)
<i>Indicated</i>							
Crude	371	7/172 (4.1)	364/5066 (7.2)	4.1 (1.1, 7.1)	7.2 (6.5, 7.9)	-3.0 (-6.1, 0.05)	0.58 (0.28, 1.20)
PS-matched ^b	398	7/172 (4.1)	32/343 (9.3)	4.1 (1.1, 7.1)	9.3 (6.2, 12.4)	-5.2 (-9.5, -0.93)	0.44 (0.20, 0.98)
PS-adjusted	367	7/172 (4.1)	360/4997 (7.2)	3.9 (1.1, 6.7)	7.2 (6.5, 7.9)	-3.3 (-6.3, -0.39)	0.54 (0.56, 1.13)
<i>IUGR Diagnosis</i>							
Crude	292	10/172 (5.8)	282/5066 (5.6)	5.9 (2.3, 9.4)	5.6 (4.9, 6.2)	0.30 (-3.3, 3.9)	1.05 (0.57, 1.94)
PS-matched ^b	31	10/172 (5.8)	21/343 (6.1)	5.9 (2.4, 9.5)	6.1 (3.6, 8.6)	-0.16 (-4.5, 4.2)	0.97 (0.47, 2.02)
PS-adjusted	285	10/172 (5.8)	275/4997 (5.5)	6.0 (2.4, 9.6)	5.5 (4.9, 6.1)	0.51 (-3.2, 4.2)	1.09 (0.59, 2.02)

^a Adjusted for race, insurance type, ADI, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score; ^c missing NICU status (n=for that analysis). missing in matched cohort; ^d Only those deemed eligible by PC06 definitions are included in the denominator. Specifically, deliveries with liveborn, term singletons, ≥ 2500 g, with no congenital malformations/pre-existing fetal conditions nor maternal drug use.

Lemon. Quantifying the association of doula care with maternal and neonatal outcomes. Am J Obstet Gynecol 2025.

Sensitivity analysis reclassifying doula care

3 or more prenatal doula visits

STABLE 13**Delivery characteristics of liveborn deliveries at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n = 17,831)**

Factor	No Doula n (%)	Doula n (%)	p-value ^b
N	17348	483	
<i>Prenatal Characteristics^a</i>			
Doula type			
Prenatal doula	306 (1.8)	483 (100)	NA
Delivery doula	216 (1.3)	349 (72.3)	<0.001
Postpartum doula	248 (1.4)	394 (81.6)	<0.001
Self-reported race			<0.001
White	12742 (73.4%)	272 (56.3%)	
Black	2934 (16.9%)	147 (30.4%)	
Other	1595 (9.2%)	60 (12.4%)	
Unknown	77 (0.4%)	4 (0.8%)	
Ethnicity			0.092
Declined	911 (5.3%)	35 (7.4%)	
Hispanic or Latino	335 (2.0%)	14 (2.9%)	
Not Hispanic or Latino	15930 (92.7%)	427 (89.7%)	
Not specified	2 (<1%)	0 (0.0%)	
Maternal age	30.6 (5.3)	30.7 (5.5)	0.54
Insurance			0.029
Commercial	12088 (69.7%)	310 (64.2%)	
Medicaid	4967 (28.6%)	162 (33.5%)	
Medicare	107 (0.6%)	2 (0.4%)	
Self-Pay/ Other	186 (1.1%)	9 (1.9%)	
Area Deprivation Index [Mean (SD)]	61.7 (24.7)	64.7 (24.8)	0.008
Nulliparous	5326 (30.7%)	173 (35.8%)	0.016
Gestational age at first visit [Median (IQR)]	64 (56, 78)	63 (54, 80)	0.23
Trimester at first visit			
First	14673 (84.6%)	403 (83.4%)	0.007
Second	1789 (10.3%)	56 (11.6%)	
Third	882 (5.1%)	24 (5.0%)	
Number of prenatal visits	11 (9, 13)	12 (10, 15)	<0.001
Pregavid weight (lbs)	153 (132, 185)	150.5 (129.5, 185.5)	0.33
Morbidly obese	1099 (6.3%)	27 (5.6%)	0.51
Chronic HTN	436 (2.5%)	14 (2.9%)	0.59
Any gestational HTN	2909 (16.8%)	78 (16.1%)	0.72
Prior to 20 weeks ^c	772 (4.5%)	28 (5.8%)	0.16
After 20 weeks	3475 (20.0%)	88 (18.2%)	0.33

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(continued)

STABLE 13

Delivery characteristics of liveborn deliveries at UPMC from 1/1/2021 through 12/31/2022 with prenatal care at UPMC (n = 17,831) (continued)

Factor	No Doula n (%)	Doula n (%)	p-value ^b
Preeclampsia	387 (2.2%)	9 (1.9%)	0.59
Prior to 20 weeks	104 (0.6%)	3 (0.6%)	0.95
After 20 weeks	1500 (8.6%)	40 (8.3%)	0.78
Diabetes T1/T2	176 (1.0%)	6 (1.2%)	0.62
GDM	1559 (9.0%)	50 (10.4%)	0.30
Anxiety	2489 (14.3%)	68 (14.1%)	0.87
Depression	2227 (12.8%)	79 (16.4%)	0.023
Tobacco use	1674 (9.6%)	41 (8.5%)	0.39
Antepartum ED	4590 (26.5%)	180 (37.3%)	<0.001
Antepartum admission	1342 (7.7%)	44 (9.1%)	0.27
<i>Delivery Characteristics</i>			
C-Section	5763 (33.2%)	171 (35.4%)	0.32
NTSV Cesarean ^d	1640 (27.4%)	74 (30.7%)	0.25
VBAC ^e	585 (18.9%)	16 (28.6%)	0.068
Maternal delivery weight	156.6 (135, 189)	155 (133, 191.4)	0.48
Birthweight ^f	3260 (2910, 3590)	3250 (2950, 3590)	0.81
IUGR	585 (3.4%)	20 (4.1%)	0.36
PTB (<37 weeks)	1870 (10.8%)	30 (6.2%)	0.001
EPTB (<34 weeks)	577 (3.3%)	6 (1.2%)	0.011
VEPTB (<28 weeks)	196 (1.1%)	0 (0.0%)	0.019
Indicated PTB	947 (5.5%)	21 (4.3%)	0.29
Spontaneous PTB	923 (5.3%)	9 (1.9%)	<0.001
Overall Inductions	6878 (39.6%)	195 (40.4%)	0.75
Obstetric HTN diagnosis	4195 (24.2%)	119 (24.6%)	0.82
Preeclampsia	1508 (8.7%)	43 (8.9%)	0.87
SMM	500 (2.9%)	13 (2.7%)	0.80
NICU at time of delivery	2801 (16.3%)	70 (14.6%)	0.33
Unexpected complication in term newborns ^g	292 (2.2%)	10 (2.6%)	0.64
Moderate	208 (1.6%)	9 (2.3%)	0.26
Severe	178 (1.3%)	6 (1.5%)	0.75
<i>Exclusive breastfeeding at discharge</i>			
<i>Postpartum follow-up^h</i>			
Office Visit	13573 (78.2%)	403 (83.4%)	0.006
EDTR	1522 (8.8%)	55 (11.4%)	0.046
Postpartum readmission	878 (5.1%)	28 (5.8%)	0.47

SD=standard deviation; IQR=interquartile range; HTN=hypertension; GDM=gestational diabetes; ED=emergency department; NTSV=nulliparous, term, singleton, vertex; VBAC=vaginal birth after cesarean; IUGR=intrauterine growth restriction; PTB=preterm birth; EPTB=early preterm birth; VEPTB=very early preterm birth; NICU=neonatal intensive care unit; PC06=Perinatal Core metric 06.

^a Missingness of variables at prenatal visit are filled in with those populated at time of delivery when available; ^b Pearson's chi-squared, Two sample t test, Wilcoxon rank sum as appropriate; ^c Excludes chronic hypertension; ^d Denominator limited to NTSV eligible (n=5997 in no doula; 241 in doula); ^e Denominator limited to deliveries with previous cesarean (n=3096 in no doula; 56 in doula); ^f Birthweight reflective of smallest infant for multiples; ^g Denominator limited to PC06 eligible (n=13257 in no doula; 392 in doula); ^h Within 6 weeks of delivery.

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STABLE 14
Risk-Adjusted frequency of maternal outcomes

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
Cesarean Delivery							
Crude	5934	171/483 (35.4)	5763/17348 (33.2)	35.1 (30.9, 39.4)	33.2 (32.5, 33.9)	1.9 (-2.4, 6.2)	1.06 (0.93, 1.19)
PS-matched ^b	495	171/483 (35.4)	324/965 (33.6)	35.5 (31.2, 39.8)	33.5 (30.6, 36.5)	2.0 (-3.2, 7.2)	1.06 (0.91, 1.23)
PS-adjusted ^c	5910	171/483 (35.4)	5739/17293 (33.2)	34.4 (30.2, 38.6)	33.2 (32.5, 33.9)	1.2 (-3.1, 5.5)	1.04 (0.91, 1.17)
NTSV Cesarean Delivery ^f							
Crude	1714	74/241 (30.7)	1640/5997 (27.4)	31.6 (25.2, 36.9)	27.3 (26.2, 28.5)	3.7 (-2.3, 9.7)	1.14 (0.94, 1.38)
PS-matched ^b	162	74/241 (30.7)	88/330 (26.7)	30.8 (24.9, 36.7)	26.6 (21.8, 31.4)	4.1 (-3.5, 11.8)	1.16 (0.89, 1.51)
PS-adjusted ^c	1709	74/241 (30.7)	1635/5977 (27.4)	29.7 (24.0, 35.4)	27.4 (26.3, 28.5)	2.3 (-3.6, 8.1)	1.08 (0.89, 1.32)
VBAC ^d							
Crude	601	16/56 (28.6)	585/3096 (18.9)	22.1 (8.5, 35.8)	19.0 (17.6, 20.4)	3.1 (-10.7, 17.0)	1.16 (0.62, 2.18)
PS-matched ^b	49	16/56 (28.6)	33/178 (18.5)	30.5 (18.3, 42.6)	18.1 (12.6, 23.7)	12.3 (-1.0, 25.7)	1.68 (1.02, 2.78)
PS-adjusted ^c	600	16/56 (28.6)	584/3085 (18.9)	28.2 (16.4, 40.1)	18.9 (17.6, 20.3)	9.3 (-2.6, 21.2)	1.49 (0.98, 2.28)
Late hypertension							
Crude	3563	88/483 (18.2)	3475/17348 (20.0)	18.4 (14.9, 21.8)	20.0 (19.4, 20.6)	-1.7 (-5.2, 1.8)	0.92 (0.78, 1.11)
PS-matched ^b	261	88/483(18.2)	173/965 (17.9)	17.8 (14.5, 21.2)	18.1 (15.7, 20.6)	-0.33 (-4.5, 3.8)	0.98 (0.78, 1.24)
PS-adjusted	3546	88/483 (18.2)	6458/17293 (20.0)	18.7 (15.2, 22.2)	20.0 (19.4, 20.6)	-1.3 (-4.9, 2.3)	0.94 (0.77, 1.13)
Late preeclampsia							
Crude	1540	40/483 (8.3)	1500/17348 (8.7)	8.1 (5.7, 10.5)	8.7 (8.2, 9.1)	-0.57 (-3.0, 1.9)	0.93 (0.69, 1.26)
PS-matched ^b	124	40/483 (8.3)	84/965 (8.7)	8.2 (5.7, 10.6)	8.8 (7.0, 10.6)	-0.62 (-3.6, 2.4)	0.93 (0.65, 1.33)
PS-adjusted	1531	40/483 (8.3)	1491/17293 (8.6)	7.7 (5.4, 10.0)	8.6 (8.2, 9.1)	-0.99 (-3.3, 1.3)	0.89 (0.65, 1.20)
Postpartum EDTR							
Crude	1577	55/483 (11.4)	1522/17348 (8.8)	10.9 (8.2, 13.7)	8.8 (8.4, 9.2)	2.2 (-0.61, 4.9)	1.26 (0.97, 1.61)
PS-matched ^b	151	55/483 (11.4)	96/965 (10.0)	11.3 (8.5, 14.1)	10.0 (8.1, 11.9)	1.3 (-2.1, 4.7)	1.13 (0.83, 1.54)
PS-adjusted ^c	1574	55/483 (11.4)	1519/17293 (8.8)	10.8 (8.1, 13.5)	8.8 (8.4, 9.2)	2.0 (-0.76, 4.7)	1.23 (0.95, 1.58)
Postpartum Readmission							
Crude	906	28/483 (5.8)	878/17348 (5.1)	5.7 (3.6, 7.7)	5.1 (4.7, 5.4)	0.61 (-1.5, 2.7)	1.12 (0.78, 1.62)
PS-matched ^b	78	28/483 (5.8)	50/965 (5.2)	5.9 (3.8, 8.0)	5.1 (3.8, 6.5)	0.76 (-1.8, 3.3)	1.15 (0.73, 1.80)
PS-adjusted	903	28/483 (5.8)	875/17293 (5.1)	5.5 (3.5, 7.5)	5.1 (4.7, 5.4)	0.41 (-1.6, 2.4)	1.08 (0.75, 1.56)

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(continued)

STABLE 14
Risk-Adjusted frequency of maternal outcomes (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
Postpartum Office Visit							
Crude	13976	403/483 (83.4)	13573/17348 (78.2)	85.0 (82.1, 87.9)	78.2 (77.6, 78.8)	6.8 (3.9, 9.8)	1.09 (1.05, 1.13)
PS-matched ^b	1144	403/483 (83.4)	741/965 (76.8)	83.5 (80.4, 86.6)	76.7 (74.2, 79.2)	6.8 (2.9, 10.8)	1.09 (1.04, 1.14)
PS-adjusted ^c	13939	403/483 (83.4)	13536/17293 (78.3)	85.3 (82.3, 88.3)	78.2 (77.6, 78.8)	7.1 (4.0, 10.1)	1.09 (1.05, 1.13)

Abbreviations: PS - propensity score, EDTR- ED treat and release.

^a Adjusted for race, insurance type, ADI, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score; ^c Limited to NTS deliveries; ^d Limited to deliveries with a previous cesarean; ^e Adjusted for propensity score and interaction between doula care with race and with insurance type.

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STABLE 15
Risk-Adjusted frequency of neonatal outcomes

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
NICU ^f							
Crude	2871	70/479 (14.6)	2801/17200 (16.3)	14.3 (11.2, 17.4)	16.3 (15.8, 16.8)	-2.0 (-5.1, 1.2)	0.88 (0.71, 1.09)
PS-matched ^b	228	70/479 (14.6)	158/953 (16.6)	14.6 (11.4, 17.7)	16.6 (14.3, 19.0)	-2.1 (-6.0, 1.9)	0.88 (0.68, 1.14)
PS-adjusted	2860	70/479 (14.6)	2790/17145 (16.3)	14.2 (11.1, 17.3)	16.3 (15.7, 16.8)	-2.1 (-5.2, 1.1)	0.87 (0.70, 1.09)
Unexpected severe complication in term newborn ^d							
Crude	184	6/392 (1.5)	178/13257 (1.3)	1.5 (0.30, 2.6)	1.3 (1.2, 1.5)	0.10 (-1.1, 1.3)	1.08 (0.48, 2.42)
PS-matched ^b	16	6/392 (1.5)	10/742 (1.4)	1.5 (0.30, 2.6)	1.4 (0.53, 2.2)	0.10 (-1.4, 1.5)	1.07 (0.39, 2.93)
PS-adjusted	183	6/392 (1.5)	177/13214 (1.3)	1.5 (0.31, 2.7)	1.3 (1.2, 1.5)	0.18 (-1.1, 1.4)	1.13 (0.50, 2.55)
Unexpected moderate complication in term newborn ^d							
Crude	217	9/392 (2.3)	208/13257 (1.6)	2.3 (0.79, 3.7)	1.6 (1.4, 1.8)	0.68 (-0.79, 2.2)	1.43 (0.74, 2.77)
PS-matched ^b	22	9/392 (2.3)	13/742 (1.8)	2.3 (0.81, 3.8)	1.8 (0.81, 2.7)	0.52 (-1.2, 2.3)	1.29 (0.56, 3.00)
PS-adjusted	214	9/392 (2.3)	205/13214 (1.6)	2.3 (0.81, 3.8)	1.6 (1.3, 1.8)	0.75 (-0.76, 2.3)	1.48 (0.76, 2.87)
Breastfeeding							
Exclusive							
Crude	6646	214/483 (44.3)	6432/17348 (37.1)	47.9 (43.6, 52.2)	37.0 (36.3, 37.7)	10.9 (6.6, 15.2)	1.29 (1.18, 1.42)
PS-matched ^b	528	214/483 (44.3)	314/965 (32.5)	44.2 (40.0, 48.4)	32.6 (29.8, 35.4)	11.6 (6.5, 16.8)	1.36 (1.19, 1.54)
PS-adjusted	6636	214/483 (44.3)	6422/17293 (37.1)	53.8 (48.9, 58.6)	43.6 (42.8, 44.4)	10.2 (5.2, 15.1)	1.23 (1.12, 1.35)
Nonexclusive							
Crude	7541	220/483 (45.6)	7321/17348 (42.2)	43.3 (38.9, 47.7)	42.3 (41.5, 43.0)	1.0 (-3.4, 5.5)	1.02 (0.92, 1.13)
PS-matched ^b	664	220/483 (45.6)	444/965 (46.0)	45.8 (41.4, 50.1)	45.9 (42.8, 49.0)	-0.15 (-5.5, 5.2)	1.00 (0.89, 1.12)
PS-adjusted	7517	220/483 (45.6)	7297/17293 (42.2)	42.8 (38.4, 47.1)	42.3 (41.5, 43.0)	0.47 (-4.0, 4.9)	1.01 (0.91, 1.12)
PTB							
Overall							
Crude	1900	30/483 (6.2)	1870/17348 (10.8)	6.0 (3.9, 8.1)	10.8 (10.3, 11.3)	-4.8 (-6.9, -2.6)	0.56 (0.39, 0.79)
PS-matched ^b	126	30/483 (6.2)	96/965 (10.0)	6.2 (4.1, 8.3)	10.0 (8.1, 11.8)	-3.8 (-6.6, -0.91)	0.62 (0.42, 0.92)
PS-adjusted	1892	30/483 (6.2)	1862/17293 (10.8)	5.8 (3.8, 7.9)	10.8 (10.3, 11.3)	-5.0 (-7.0, -2.9)	0.54 (0.38, 0.77)

Lemon. Quantifying the association of doula care with maternal and neonatal outcomes. Am J Obstet Gynecol 2025.

(continued)

STABLE 15
Risk-Adjusted frequency of neonatal outcomes (continued)

Model	No.	Total Visits/Total, No. (%)		Risk-Adjusted ^a frequency per 100 deliveries (95%CI)		Risk Difference, per 100 deliveries (95% CI)	Risk Ratio (95% CI)
		Doula	No Doula	Doula	No Doula		
<i>Spontaneous</i>							
Crude	932	9/483 (1.9)	923/17348 (5.3)	1.8 (0.63, 3.0)	5.3 (5.0, 5.7)	-3.5 (-4.7, -2.3)	0.36 (0.18, 0.64)
PS-matched ^b	60	9/483 (1.9)	51/965 (5.3)	1.9 (0.66, 3.1)	5.3 (3.9, 6.7)	-3.4 (-5.3, -1.6)	0.35 (0.18, 0.71)
PS-adjusted	930	9/483 (1.9)	921/17293 (5.3)	1.9 (0.66, 3.1)	5.33 (5.0, 5.7)	-3.5 (-4.7, -2.2)	0.35 (0.18, 0.67)
<i>Indicated</i>							
Crude	968	21/483 (4.4)	947/17348 (5.5)	4.3 (2.5, 6.1)	5.5 (5.1, 5.8)	-1.2 (-3.0, 0.62)	0.78 (0.51, 1.19)
PS-matched ^b	66	21/483 (4.4)	45/965 (4.7)	4.3 (2.5, 6.1)	4.7 (3.4, 6.0)	-0.35 (-2.6, 1.9)	0.92 (0.56, 1.53)
PS-adjusted	962	21/483 (4.4)	941/17293 (5.4)	4.4 (2.5, 6.2)	5.4 (5.1, 5.8)	-1.1 (-2.9, 0.76)	0.80 (0.52, 1.22)
<i>IUGR Diagnosis</i>							
Crude	605	20/483 (4.1)	585/17348 (3.4)	3.8 (2.2, 5.4)	3.4 (3.1, 3.7)	0.42 (-1.2, 2.1)	1.12 (0.73, 1.74)
PS-matched ^b	53	20/483 (4.1)	33/965 (3.4)	4.1 (2.4, 5.9)	3.4 (2.3, 4.6)	0.72 (-1.4, 2.8)	1.21 (0.71, 2.08)
PS-adjusted	601	20/483 (4.1)	581/17293 (3.4)	4.1 (2.4, 5.9)	3.4 (3.1, 3.6)	0.78 (-1.0, 2.6)	1.23 (0.80, 1.91)

^a Adjusted for race, insurance type, ADI, nulliparity, trimester all at the time of the first prenatal visit; ^b Matched 2:1 (no doula:doula) on propensity score; ^c 152 missing NICU status (n=17,679 for that analysis); ^d Only those deemed eligible by PC06 definitions are included in the denominator. Specifically, deliveries with liveborn, term singletons, ≥2500 g, with no congenital malformations/pre-existing fetal conditions nor maternal drug use.

Lemon. Quantifying the association of doula care with maternal and neonatal outcomes. *Am J Obstet Gynecol* 2025.