OBSTETRICS

Evaluating the impact of the laborist model of obstetric care on maternal and neonatal outcomes

Sindhu K. Srinivas, MD, MSCE; Dylan S. Small, PhD; Michelle Macheras, MS; Jesse Y. Hsu, PhD; Donna Caldwell, PhD; Scott Lorch, MD, MSCE

BACKGROUND: The laborist model of obstetric care represents a change in care delivery with the potential of improving maternal and neonatal outcomes.

OBJECTIVE: We evaluated the effectiveness of the laborist model of care compared to the traditional model of obstetric care using specific maternal and neonatal outcome measures.

STUDY DESIGN: This is a population cohort study with laborist and nonlaborist hospitals matched 1:2 on delivery volume, geography, teaching status, and neonatal intensive care unit level using data from the National Perinatal Information Center/Quality Analytic Services database. A before-and-after study design with an untreated comparison group analyzed with the method of difference-in-differences was used to examine the impact of laborists on maternal and neonatal outcome measures within the 3 years after implementing the laborist system, after adjusting for secular trends, sociodemographic factors, and maternal medical conditions. The final outcome measures evaluated included cesarean delivery, chorioamnionitis, induction of labor, preterm birth, prolonged length of stay, Apgar at 5 minutes of <7, birth asphyxia, birth injury, birth trauma, and neonatal death.

RESULTS: We studied nearly 550,000 women from 24 hospitals (8 laborist and 16 nonlaborist hospitals) from 1998 through 2011. Implementation of laborists was associated with fewer labor inductions (adjusted odds ratio, 0.85; 95% confidence interval, 0.71—0.99) and decreased rate of preterm birth (adjusted odds ratio, 0.83; 95% confidence interval, 0.72—0.96) after controlling for confounders. Laborists did not impact the cesarean delivery rate, chorioamnionitis, or prolonged length of stay.

CONCLUSION: Implementation of the laborist model was associated with a significant reduction in labor induction rate and preterm birth without adversely affecting other outcomes.

Key words: laborist, maternal and neonatal outcomes, obstetrics, pregnancy

Introduction

Childbirth is one of the most common reasons for hospital care with >4 million births annually in the United States.[1] Nearly 10% of births have complications,[2] with many having serious consequences such as unintended maternal or neonatal intensive care unit admission, maternal blood transfusion, or birth asphyxia. The laborist or obstetrician/gynecologist hospitalist model of care, introduced over a decade ago, is a growing[3,4] but unproven alternative model of care, with proponents hypothesizing it will enhance patient safety and outcomes. While variations in the implementation of the model exist, a laborist model generally refers to the presence of a labor and delivery provider for a set period of time, whose sole focus is on the labor and delivery unit without other competing clinical duties. The newly developed Society of OB/GYN Hospitalists (SOGH) (societyofobgynhospitalists.com) demonstrates evidence of the growth of the laborist movement. SOGH defines this practitioner as an obstetrician/gynecologist who has focused his or her professional practice on the care of women in labor and delivery.

The laborist model was based on the internal medicine hospitalist model where physicians spend >25% of their time caring for inpatients. Studies of the internal medicine hospitalist model have shown improved costs and possibly improved outcomes,[5] although the literature supporting improved outcomes has been inconsistent.[6,7] While there are no studies specifically evaluating the impact of implementing a laborist (obstetrician/gynecologist hospitalist) model on maternal and neonatal outcomes, other evidence suggests that improvements in outcomes with this model are plausible. As an example, some intrapartum deaths are thought to result from suboptimal management of labor and delivery where timely recognition and management may have prevented the death from occurring.[8-11] Additionally, early recognition of many peripartum events including infection, hemorrhage, and obstructed labor can result in the reduction in maternal and infant mortality during labor, delivery, and neonatal periods.[11] This evidence suggests a framework and mechanism by which a laborist model may improve patient outcomes. Our objective was to evaluate the effectiveness of the laborist model of care compared to the traditional model of obstetric care using specific maternal and neonatal process and outcome measures, with participants selected based on information from the National Perinatal Information Center (NPIC)/Quality Analytic Services (QAS) 2010 cross-sectional survey of their 74 member hospitals.[12]

Materials and Methods

Study design

We performed a cohort study to compare pregnancy outcomes of women delivering at unexposed (nonlaborist) hospitals vs those delivering at exposed

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(laborist) hospitals, using data from NPIC/QAS from 1998 through 2011. The NPIC/QAS is a voluntary benchmarking organization that began in 1985 with a charter membership of major perinatal centers across the United States. Within the group, the average annual delivery volume was 4619 per hospital with a range of 589-16,544 annual deliveries per hospital. The characteristics of women delivering at member hospitals represent the general US population with 70% between the ages of 21-35 years and approximately 40% unmarried.[13] At the time the 2010 cross-sectional survey was performed, NPIC/QAS had 74 member hospitals from 26 states.[14] NPIC/QAS has key contacts at each of their member institutions. The survey was completed by those identified at each institution to be the best qualified to complete the instrument.

Exposure status (implementation of laborists) during the time frame and the timing of exposure implementation was based on the response to a specific question on their cross-sectional survey: "Do hospitalists/laborists perform deliveries?"[12] Sixteen NPIC/QAS member hospitals indicated on their member survey that hospitalists/laborists were performing deliveries in 2011. NPIC/QAS staff approached these hospitals to participate in the study, which verified the accuracy of the exposure (laborist/nonlaborist) designation and determined when the hospitals initiated the laborist system at their institution. Of these 16, 8 hospitals made up the final cohort. Four hospitals expressed interest but were unable to obtain internal buy-in prior to closure of enrollment, and 1 laborist hospital declined. The 3 remaining hospitals agreed to participate, but they did not have sufficient data after the implementation of the laborist program for inclusion in the study. The 8 laborist hospitals in this study implemented laborists in the years 2000, 2004, 2006 (2), 2007, 2008, 2009, and 2010.

We then used a matched sampling methodology to select eligible hospitals from the NPIC/QAS membership. Matched sampling is a cost-efficient way of comparing a treatment (laborist) group to a control (nonlaborist) group when there are considerably more control units than treated units; by matching multiple control units to each treated unit, we obtain almost as powerful a study as if we had used all control units at a fraction of the cost.[15-17] Hospitals were matched 2:1 nonlaborist to laborist using the variables:

1) Annual volume of deliveries categorized as $\leq$1000 or $>$1000.
2) Geography based on US census bureau designated areas: Northeast, Midwest, South, West.
3) Teaching hospital status (presence of obstetrics residents).
4) Level of neonatal intensive unit care.

Each of these factors has been associated with changes in maternal/neonatal outcomes, the possibility of moving to a laborist system, or both.[18-22] Thus, including these criteria in our match minimized other differences between laborist and nonlaborist hospitals that may be associated with maternal or neonatal outcomes.

Of the 16 nonlaborist NPIC/QAS member hospitals approached as potential matches for the laborist sites, only 1 hospital declined to participate and was replaced with the second choice hospital. After hospitals consented, maternal and neonatal discharge data from all 24 participating hospitals were obtained in a de-identified data set. The 3 hospitals in each triad (1 laborist and 2 nonlaborists) each contributed at least 3 years of data in the preimplementation period and up to 2 years of data in the postimplementation period, with the assignment of the periods for each triad based on the calendar year of laborist hospital implementation (implementation is year 0) within that triad. Available NPIC/QAS data included patient-level data submitted on all perinatal discharges by member hospitals for each quarter. NPIC/QAS processed the data and each hospital signed off on data accuracy prior to its final inclusion in the NPIC/QAS data set. The file was composed of discharge abstract/UB 04 data. Per NPIC/QAS protocol, maternal hospitalizations were linked using either medical record or billing number to the corresponding infant hospitalization. The primary investigator and analysis team were blinded to hospital identity.

Outcomes and covariates

Outcome measures were chosen based on their public health relevance, measures of patient safety, or measures of the relative health of the mother or infant. The *International Classification of Diseases, Ninth Revision* (*ICD-9*)-*Clinical Modification* (*CM*) codes or other data fields used to identify each outcome are listed in Table 1. Maternal outcome measures included pregnancy complications (eg, postpartum hemorrhage [defined by *ICD-9* codes corresponding to an estimated blood loss $>$500 mL for a vaginal delivery or $>$1000 mL for a cesarean delivery], infection, or need for intensive care admission); Agency for Health Care Research and Quality patient safety indicators such as significant perineal lacerations; and preterm birth, both spontaneous and medically indicated. Preterm birth was defined using diagnosis codes for preterm birth $<$37 weeks. Medically indicated preterm births were defined as those with the diagnoses codes for intrauterine growth restriction, pregnancy-related hypertension, and previa/abruption. Neonatal outcomes included birthweight at delivery, mortality, birth injury, and neonatal intensive care admission.

Final outcomes were chosen after 1 additional step. To minimize the bias of not attributing an already existing trend to the implementation of laborists, we examined the difference in each outcome measure between laborist and their matched nonlaborist hospitals during the 3 years before the implementation of the laborist program. We excluded any outcome measures where there was a statistically significant change between laborist and nonlaborist hospitals during the 3-year preimplementation time period. Including these measures could inappropriately attribute the change to the initiation of the laborist model at that hospital, when in fact there was an already existing secular trend prior to laborist implementation. The final maternal and

neonatal outcomes evaluated include: cesarean delivery, chorioamnionitis, induction of labor, preterm birth, maternal prolonged length of stay (>2 days postpartum for vaginal delivery; >4 days postpartum for cesarean delivery), Apgar at 5 minutes of <7, birth asphyxia, injury, trauma, and neonatal death.

Measured covariates used for risk adjustment were those demonstrated to be associated with the exposure or outcome. These included socioeconomic variables such as insurance status; year of delivery; maternal comorbid conditions and complications around delivery such as hypertension and diabetes; and birthweight for neonatal outcomes. *ICD-9-CM* codes and other specified data fields were used to identify these covariates (Table 1).

Statistical approach

We used a before-and-after study with an untreated comparison group to examine whether the implementation of the laborist model at a hospital was associated with a change in the underlying trend in patient outcomes in the hospital,[23,24] also known as a difference-in-differences approach.[25] Here, we examined how the baseline risk-adjusted rate of each outcome changed in the laborist hospital after implementation of this program, compared to the change in such outcomes *at the same time* in similar hospitals that did not implement such a program. The before-and-after study design with an untreated comparison group analyzed with the method of difference-in-differences improves the ability to determine causality by preventing bias from 3 possible sources.[24,26,27] First, a difference between laborist and nonlaborist hospitals that is stable over time cannot be mistaken for an effect of the introduction of the laborist, because data from both the preimplementation and postimplementation period are included in the model. Second, by including year indicators in the logistic model, changes over time that effect all hospitals similarly such as overall national increase in operative delivery cannot be mistaken for an effect of the laborist. Third, the effect of differential changes to the mix

TABLE 1
Codes for outcomes and comorbid conditions

Variable name	Identifying *ICD-9* codes if applicable
Maternal outcomes	
Induction of labor rate	73.01, 73.1, 73.4
Cesarean delivery rate	654.2, 669.7, 370, 371
Complications of labor induction	763.7, 763.82
Transfer to ICU	Calculated
Prolonged length of stay	Calculated
Postpartum hemorrhage/blood transfusion	666.0, 666.1, 666.2, 99.0X
Chorioamnionitis/endometritis	658.4, 670, 646.6
Wound infection	674.1 (Cesarean), 674.2 (vaginal)
Third- or fourth-degree perineal lacerations	664.2, 664.3
Modified Adverse Outcome Index	Calculated
ICU admission	Calculated
Days in hospital	Calculated
Hospital readmission within 1 wk of discharge	Calculated
Neonatal outcomes	
NICU/intermediate care admission	Submitted
1- and 5-min Apgar scores	Submitted
Neonatal mortality	Calculated from discharge disposition
Fetal mortality	779.9, 798.1, 669.9
Preterm delivery	644.2
Birth injury (nerve and other)	767.5, 6, 7, 8, 9
Birth asphyxia	768.1, 3, 4, 5, 6, 7, 768.9
Prolonged length of stay	Calculated
Necrotizing enterocolitis	777.5
Bacterial sepsis	771.81, 771.83
Meningitis	Calculated from multiple types
Any fracture	767.2 (Clavicle), 767.3 (other), 767.4 (spine)
Comorbid conditions	
Birthweight	Numeric or fifth digit 764 or 765
Gestational age	765.2 or Submitted
Maternal marital status	Submitted
Maternal race	Submitted
Maternal insurance status	Submitted
Gravida	Submitted
Parity	Submitted
Disorders of placentation	641.2, 641.0, 762.0, 762.1

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of patients at different hospitals will not be attributed to the implementation of the laborist model if these changes are accurately reflected in measured risk factors.

For each outcome of interest, we fitted a logistic regression with an interaction term of laborist status and an indicator for before/after the change, after adjusting for fixed effects for hospital, year, and patient risk factors. Huber-White robust SE (synonymous with generalized estimating equation sandwich SE) accounted for clustering by hospital (the nonindependence of patients treated at the same hospital).[28] The effect of the laborist, presented as odds ratios (ORs), measured the degree to which the outcome changed in laborist vs nonlaborist hospitals after adjusting for confounders.

Results

Nearly 550,000 patients were evaluated from 24 hospitals. Hospital-level characteristics were largely balanced after the match with a few small nonsignificant differences related to delivery volume and geography (Table 2). For patient characteristics, there were differences in maternal age, hypertension, diabetes, and insurance status between the laborist and matched nonlaborist hospitals that did not change after the laborist model was implemented (Table 3).

Table 4 demonstrates the unadjusted results for each outcome. Both laborist and nonlaborist hospitals had an increase in cesarean delivery and induction of labor in the postimplementation period. However, the change in these outcomes at hospitals that implemented a laborist model was smaller than at the matched nonlaborist hospitals. For cesarean delivery, this increase was 33% of the change in the nonlaborist hospitals (1.07% vs 3.22%, $P = .011$), while for induction of labor this increase was 17% of the change (0.68% vs 3.9%, $P = .09$). Rates of preterm delivery declined in laborist hospitals by 0.68%, while they increased in nonlaborist hospitals by 0.99% ($P = .04$). There were no unadjusted differences between the laborist and nonlaborist hospitals in other outcomes measures (Table 4).

TABLE 1
Codes for outcomes and comorbid conditions *(continued)*

Variable name	Identifying *ICD-9* codes if applicable
Pregnancy-induced hypertension	642.3
Chronic hypertension	642.2
Eclampsia	642.6
Multiple gestation pregnancy	V310, 320, 340, 350, 360, 370
Antepartum hemorrhage	641.3, 641.8, 641.9
Chorioamnionitis	658.4
Premature labor	644.0 (Threatened) and 644.2 (early onset)
Oligohydramnios	658.0
Premature/prolonged rupture of membranes	658.1, 658.2
Use of tobacco, alcohol, or illicit drugs during pregnancy	649.0, 648.3
Maternal medical conditions	
Hypertension	642.1
Diabetes mellitus	648.0
Liver disorders	646.7
Congenital heart disease	648.5
Asthma	493.0
Renal disease	646.2
Collagen vascular diseases/lupus	695.4
Presence of major congenital anomaly	740–759.9

ICD-9, *International Classification of Diseases, Ninth Revision*; *ICU*, intensive care unit; *NICU*, neonatal intensive care unit.
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Table 5 shows the adjusted OR (AOR) for the effect of implementing a laborist model on each outcome. After adjusting for observed confounders, the implementation of the laborist model was associated with a 15% decrease in the odds of inductions of labor (95% confidence interval [CI], 0.71–0.99) and a 17% decrease in the odds of preterm births (95% CI, 0.72–0.96). To further explore the reduction in preterm births, we evaluated medically indicated and spontaneous preterm births separately. In adjusted analyses, implementation of the laborist model was associated with a reduction in spontaneous preterm births (AOR, 0.85 [95% CI, 0.74-0.98]) but not medically indicated preterm births (AOR, 0.84 [95% CI, 0.60-1.18]). We next evaluated this association using categories of birthweight. There were no statistically significant differences in the rates of delivering infants <1500 g (AOR, 0.93; [95% CI, 0.70–1.22]) or infants between 1500-2500 g (AOR, 0.88 [95% CI, 0.78–1.01]) in the laborist hospitals after implementation of the program. There was no significant difference in neonatal outcomes between laborist and nonlaborist hospitals.

Comment

The implementation of laborists has led to a large shift in the way providers and patients experience obstetric care delivery. Since its inception, increased safety and potentially decreased liability have been cited as potential positives, with decreased patient satisfaction and increased patient handoffs as potential

TABLE 2
Hospital characteristics prematching and postmatching

	Prematch			Postmatch		
	Nonlaborist hospitals, % (N) N = 43	Laborist hospitals, % (N) N = 25	*P* value[a]	Nonlaborist hospitals, % (N) N = 16	Laborist hospitals, % (N) N = 8	*P* value
Volume-2 categories						
≤1000	9 (4)	4 (1)	.64	13 (2)	13 (1)	1.00
>1000	91 (39)	96 (24)		88 (14)	88 (7)	
Volume-3 categories						
≤2500	32.6 (14)	24 (6)	.003	75 (12)	38 (3)	.19
2501—5000	53.4 (23)	24 (6)		19 (3)	38 (3)	
>5000	14 (6)	52 (13)		6 (1)	25 (2)	
Residents/fellows	76.7 (33)	60 (15)	.17	88 (14)	88 (7)	1
Geography						
Northeast	30 (13)	32 (8)	.94	13 (2)	38 (3)	.26
Midwest	16.4 (7)	13 (3)		13 (2)	25 (2)	
South	37.2 (16)	44 (11)		50 (8)	38 (3)	
West	16.3 (7)	13 (3)		25 (4)	0 (0)	
NICU level						
I	5 (2)	0 (0)	.36	13 (2)	0 (0)	.41
IIA	0 (0)	8 (2)		0 (0)	13 (1)	
IIB	7 (3)	12 (3)		0 (0)	0 (0)	
IIIA	7 (3)	4 (1)		0 (0)	0 (0)	
IIIB	67 (29)	56 (14)		88 (14)	88 (7)	
IIIC	14 (6)	20 (5)		0 (0)	0 (0)	

NICU, neonatal intensive care unit.

[a] Computed using Fisher exact test.

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negatives.[3] This study rigorously assesses the impact of laborists on maternal and neonatal outcomes using validated study variables and patients from multiple sites. We found that laborists may reduce inductions of labor and preterm birth without any increase in adverse outcomes. Additionally, it is also important to state that in this study of more than a half million patients, there does not appear to be significant differences in adverse maternal or neonatal outcomes between laborist and nonlaborist hospitals.

These results are plausible. The potential reduction in inductions could result from changes in practice behavior secondary to continuous coverage and less pressure to schedule deliveries for convenience because of office hours or personal conflicts. Potential reductions in both inductions of labor and preterm birth have major public health benefits. While labor induction is sometimes medically indicated, it historically has been done for nonmedical indications. In the United States, labor inductions rose from 9.5% in 1990 to 22.1% in 2004.[29] Several studies demonstrated an increased risk of cesarean delivery with labor induction,[29] which may have significant negative future reproductive consequences.[30-32] Preterm birth is currently the leading cause of neonatal mortality and a significant contributor to neonatal morbidity. More recent interventions have focused on decreasing the rate of spontaneous preterm birth through antenatal interventions such as cervical length screening and progesterone, not specifically care on labor and delivery.[33]

Therefore, the reduction in spontaneous preterm birth is not fully explained through the data. There are few data to indicate that physicians around the time of delivery can have a significant impact at reducing the rate of extreme spontaneous premature delivery, although tocolytic drugs may delay delivery to allow for the administration of antenatal corticosteroids.[34] There is growing evidence, though, that physician practice may influence the

TABLE 3
Patient-level characteristics at hospitals before and after implementation of the laborist model in the laborist hospital

	Nonlaborist before, % (N)	Laborist before, % (N)	*P* value	Nonlaborist after, % (N)	Laborist after, % (N)	*P* value
Mean maternal age, y	27.3 ± 6.19	29.61 ± 6.04	<.001	27.62 ± 6.15	29.77 ± 5.97	<.001
Insurance						
Medicaid	6.99 (11,297)	5.49 (7894)	<.001	5.78 (7596)	2.43 (2519)	<.001
Uninsured	5.81 (9396)	3.84 (5529)	<.001	3.60 (4728)	3.15 (3262)	<.001
Asthma	0.01 (14)	0.00 (2)	.006	0.01 (20)	0.01 (12)	.460
Heart disease, lupus, renal disease	0.27 (437)	0.29 (414)	.364	0.35 (465)	0.30 (313)	.035
Diabetes or chronic hypertension	1.2 (1932)	0.9 (1284)	<.001	1.4 (1857)	0.9 (942)	<.001
Multiple gestation	1.7 (2798)	2 (2928)	<.001	1.9 (2561)	2.2 (2252)	<.001
Preeclampsia or pregnancy-induced hypertension	10.95 (17,842)	9.23 (13,387)	<.001	11.55 (15,408)	9.33 (9771)	<.001
Congenital anomalies	8.02 (12,940)	7.56 (11,233)	<.001	8.57 (11,679)	8.47 (9092)	.4135

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delivery of infants late preterm between 34-37 weeks' gestation. These infants have recently been identified as having a higher risk of respiratory distress, poor feeding, and prolonged hospitalization.[35-38] Laborists may have more complete knowledge of this literature and change their patterns of delivery to reduce this risk specifically to this late preterm group, which represents the majority of preterm deliveries. Our data support this theory: the rates of infants born <2500 g regardless of reason did not change after implementation of the laborist model, suggesting that any reduction in preterm deliveries occurred in larger, older infants. This could plausibly be through less augmentation of late preterm patients. Improved collection of gestational age data would confirm this hypothesis. Further work will be needed to test for specific differences in practices around late preterm delivery at institutions using laborist models of care. Additionally, hospitals that choose to adopt a laborist model may be quicker to adopt therapies that are known to reduce spontaneous preterm births such as initiation of 17-hydroxyprogesterone weekly intramuscular injections in those women with a prior preterm birth.[39]

Finally, the rate of increase in cesarean delivery was reduced in unadjusted analyses, but was not reduced after adjusting for measured case mix. This

TABLE 4
Unadjusted results

	Nonlaborist before, % (N)	Nonlaborist after, % (N)	Change	Laborist before, % (N)	Laborist after, % (N)	Change	*P* value
Cesarean delivery	28.53 (46,486)	31.75 (42,348)	+3.22	32.55 (47,206)	33.62 (35,210)	+1.07	.011
Chorioamnionitis	6.15 (10,018)	4.75 (6339)	−1.4	3.83 (5549)	3.46 (3814)	−0.37	.077
Induction of labor	16.10 (26,232)	20.01 (26,681)	+3.9	21.17 (30,709)	21.85 (22,880)	+0.68	.094
Preterm birth	9.88 (16,094)	10.87 (14,498)	+0.99	8.74 (12,675)	8.07 (8455)	−0.68	.046
Maternal prolonged length of stay	24.16 (39,354)	26.15 (34,876)	+1.99	21.37 (31,002)	21.49 (22,512)	+0.12	.259
Apgar 5<7	0.35 (557)	0.35 (476)	0	0.15 (216)	0.21 (223)	+0.06	.214
Birth asphyxia	0.25 (398)	0.18 (247)	−0.07	0.21 (310)	0.16 (171)	−0.05	.904
Birth injury	0.42 (677)	0.50 (687)	+0.08	0.28 (411)	0.26 (279)	−0.02	.253
Birth trauma	0.31 (500)	0.26 (350)	−0.05	0.24 (356)	0.28 (304)	+0.04	.132
Birthweight <1500 g	2.39 (3858)	2.50 (3404)	+0.11	1.99 (2961)	2.13 (2288)	+0.14	.847
Birthweight 1500−2500 g	5.22 (8216)	5.66 (7524)	+0.44	5.29 (7704)	5.27 (5532)	−0.02	.176

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finding contrasts with a prior study that compared cesarean delivery rates between a private practice model and a midwife-laborist model at a single community hospital. They found that cesarean rates were lower in the midwife-laborist model. However, the private practice patients in this study were notably older, and more likely to be nulliparous, both of which are potential biologic reasons for an increased cesarean delivery rate. Our study also specifically controlled for the increased overall rate of operative deliveries during the study time period. The prior study did not control for these trends, which could have explained the differences in these results.[40] Our study also differs from a study that evaluated cesarean delivery rate with 3 different staffing models in a single tertiary center.[41] This study found that full-time laborists had an approximately 5% lower cesarean delivery rate among low-risk women compared to community laborists and a traditional staffing model. Thus, this study suggests that the type of laborist model may influence cesarean delivery. However, in a single-center model, generalizing these results to multiple centers is difficult given the fact that, in a single center, there may be unreported reasons for making such changes that do not apply to other facilities. Additionally, most of the hospitals included in our study were academic hospitals, which may make our study most generalizable to those hospitals. Finally, both of the previously mentioned studies are single center and the number of hospitals from a variety of geographic regions with various delivery volumes and maternal and neonatal capabilities included in our current study provides a more generalized assessment of the impact of laborists on maternal and neonatal outcomes.

We must acknowledge some limitations. Administrative data have several advantages and disadvantages for this type of study. While administrative data use *ICD-9-CM* codes that lack the detail of chart abstraction, they allow for a larger sample size to be evaluated. They also offer standard data nationally and allow for a more robust inclusion of patients. Additionally, a rigorous study design to assess differences in outcomes after implementation of a model of care change (ie, laborist) requires a large number of hospitals. This would be much less efficient and difficult to accomplish without using administrative data. However, because of data restraints, we were unable to get the specific gestational ages at time of delivery consistently for all hospitals included in this study, but were able to use the code for preterm birth for all hospitals to analyze data by broad birthweight categories. Finally, we evaluated overall cesarean delivery rate and not low-risk cesarean delivery rate. It is possible that, if low-risk cesarean delivery rate is evaluated specifically, there may be a difference. However, it is unlikely that the parity mix or other factors influencing this changed drastically within each hospital to account for the lack of a difference in overall cesarean delivery rate with implementation of laborists. However, this should be evaluated in future work.

Studies from selected centers[42-45] are potentially biased by patient and physician factors that influence the choice of a delivery hospital. In our study, we obtained individual infant and maternal-level data from 24 geographically varied hospitals. However, they are select hospitals that are members of NPIC/QAS. Certain hospital-level characteristics may influence the propensity for a hospital to move to a laborist model. However, our algorithm to match on 4 hospital-level factors reduces this bias as suggested by Vintzileos and colleagues.[46] While the NPIC/QAS members are a select group of hospitals, they represent 26 states and a wide range of geographies and annual delivery volumes. Finally, a single-hospital prelaborist/postlaborist design would be less generalizable than our multicenter design and not have an unaffected control group to control for confounding by time. This study design provides stronger evidence of the potential association between laborist model and outcomes vs other observational study designs. We must acknowledge however, that while we have established an association, the association may not be causal due to unmeasured biases that could affect a difference-in-difference design

TABLE 5
Robust SE adjusted results

	Adjusted odds ratios [95% confidence intervals][a,b]
Cesarean delivery	1.02 [0.97–1.1]
Chorioamnionitis	1.07 [0.88–1.30]
Induction of labor	0.85 [0.71–0.99][c]
Preterm birth	0.83 [0.72–0.96][c]
Maternal prolonged length of stay	0.99 [0.87–1.14]
Apgar 5 min <7	1.09 [0.69–1.72]
Birth asphyxia	0.75 [0.48–1.18]
Birth injury	0.77 [0.56–1.07]
Birth trauma	1.32 [0.91–1.92]
Birthweight <1500 g	0.93 [0.70–1.22]
Birthweight 1500–2500 g	0.88 [0.78–1.01]

Confounding variables included for neonatal outcomes: year, hospital identification, insurance, multiple gestation, congenital anomaly, birthweight.

[a] Confidence intervals based on robust SE that account for clustering by hospital; [b] Confounding variables included for maternal outcomes: year, hospital identification, maternal age, insurance, pregnancy-related hypertension, chronic hypertension, oligohydramnios, premature rupture of membranes, liver disease, heart disease, asthma, renal disease, lupus, preterm labor; [c] Included in all models except preterm delivery model.

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such as differential trends between the laborist and nonlaborist hospitals, although we also attempted to account for that in our selection of outcomes without preexisting trends. Further, we ascertained the exposure status of laborists from hospital report without information regarding specific duties of laborists such as shift length and patients covered, which limits our ability to comment on different methods of implementation of laborists unlike 1 prior single-center study.[41]

In summary obstetric care is rapidly evolving with increasing utilization of laborists. Our study demonstrates that the laborist model is a promising obstetric care delivery model that may decrease the adverse outcomes and cost of obstetric care through a possible reduction in inductions and preterm birth. Additional studies are needed to evaluate the impact of this model in different settings and to further understand the mechanism by which these outcomes are possibly improved. If we can understand the mechanism of these outcome improvements these lessons may be transferrable and assist in achieving optimal maternal and neonatal outcomes even in settings without laborists. ■

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Author and article information

From the Department of Obstetrics and Gynecology, Maternal and Child Health Research Program (Dr Srinivas), and Leonard Davis Institute of Health Economics (Drs Srinivas, Small, Hsu, and Lorch), University of Pennsylvania, Philadelphia, PA; Center for Outcomes Research, Children's Hospital of Philadelphia, Philadelphia, PA (Drs Small, Hsu, and Lorch and Ms Macheras); Division of Neonatology, Department of Pediatrics, Children's Hospital of Philadelphia, Philadelphia, PA (Dr Lorch); and National Perinatal Information Center/Quality Analytic Services, Providence, RI (Dr Caldwell).

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Corresponding author: Sindhu K. Srinivas, MD, MSCE.
ssrinivas@obgyn.upenn.edu