Outcomes, Safety, and Resource Utilization in a Collaborative Care Birth Center Program Compared With Traditional Physician-Based Perinatal Care

Debra J. Jackson, RN, MPH, DSc, Janet M. Lang, PhD, ScD, William H. Swartz, MD, Theodore G. Ganiats, MD, Judith Fullerton, CNM, PhD, Jeffrey Ecker, MD, and Uyensa Nguyen, MPH

Objective. We compared outcomes, safety, and resource utilization in a collaborative management birth center model of perinatal care versus traditional physician-based care.

Methods. We studied 2957 low-risk, low-income women: 1808 receiving collaborative care and 1149 receiving traditional care.

Results. Major antepartum (adjusted risk difference [RD]=–0.5%; 95% confidence interval [CI]=–2.5, 1.5), intrapartum (adjusted RD=0.8%; 95% CI=–2.4, 4.0), and neonatal (adjusted RD=–1.8%; 95% CI=–3.8, 0.1) complications were similar, as were neonatal intensive care unit admissions (adjusted RD=–1.3%; 95% CI=–3.8, 1.1). Collaborative care had a greater number of normal spontaneous vaginal deliveries (adjusted RD=14.9%; 95% CI=11.5, 18.3) and less use of epidural anesthesia (adjusted RD=–35.7%; 95% CI=–39.5, –31.8).

Conclusions. For low-risk women, both scenarios result in safe outcomes for mothers and babies. However, fewer operative deliveries and medical resources were used in collaborative care. (*Am J Public Health.* 2003;93:999–1006)

The National Birth Center Study[1] and other studies comparing birth center deliveries with traditional hospital deliveries[2–7] report favorable outcomes and fewer obstetric interventions in the birth center groups. These studies have been considered inconclusive because of concern that women choosing to deliver at a birth center may have been healthier than women seeking traditional perinatal care.[8,9] In our study we evaluated the safety and resource utilization of a practice model that included collaborative certified nurse–midwife (CNM)/obstetrician management of perinatal care and a freestanding birth center option for delivery. We paid rigorous attention to the initial perinatal risk of all the women in the study.

METHODS

The current study, the San Diego Birth Center Study (SDBCS), was a prospective cohort study with a concurrent comparison group. The study population was low-income pregnant women and their infants who presented for prenatal care and delivery at several study sites. The follow-up period was from entry into prenatal care through 6 weeks postpartum. We compared 2 study programs: collaborative management/birth center care and traditional care.

Collaborative Management/Birth Center Care

The collaborative management/birth center care model of perinatal services (abbreviated as collaborative care) had 3 primary components: (1) a collaborative practice of CNMs and obstetricians, (2) comprehensive perinatal services including case management, health education, nutrition counseling, and social services, and (3) the option of delivering at a freestanding birth center (The BirthPlace, located in San Diego, Calif) for women who remained at low perinatal risk. These components were integrated within the health care delivery system, which included private medical offices, neighborhood health centers, and community and tertiary hospitals.

In the collaborative care model, obstetricians and CNMs were part of the same practice. CNMs provided 95% of prenatal care at 12 clinic sites. During antepartum care, 30% of participants saw only CNMs, 65% were collaboratively managed through consultation or necessary visits with an obstetrician, and 5% required exclusive antepartum management by an obstetrician.[10] In the intrapartum setting, women who remained at low risk and who delivered their babies at the freestanding birth center were managed (or co-managed) by CNMs, whereas women referred to the hospital were managed and delivered by collaborating obstetricians.

Medically eligible women were given the option to enroll in the birth center program at the beginning of prenatal care, with the majority (65%–75%) choosing birth center delivery. Of these women, 45.3% remained at low perinatal risk and delivered at a birth center. The remainder developed conditions antepartum (27.2%) or intrapartum (18.5%) that necessitated transfer to a hospital for delivery. A few (8.5%) transferred to the hospital program for reasons related to patient choice (they changed their mind or wanted epidural analgesia), primarily in the antepartum period.

Comprehensive perinatal services were modeled on California's Comprehensive Perinatal Services Program (CPSP).[11] Perinatal coordinators[11] provided case management for all of the women. Consultation with nutritionists, social workers, and health educators was based on the medical and psychosocial needs of each woman.

With more than 500 deliveries per year, The BirthPlace was the largest nationally accredited[12] freestanding birth center in the United States. It was located within 15 minutes of 3 tertiary hospitals. The birth center provided a homelike, "low-tech" environment. Intermittent Doppler auscultation of fetal heart tones was used in accordance with stan-

dards of the American College of Obstetricians and Gynecologists. Ambulation, continuous emotional support, warm tub baths, and narcotic analgesics were used to assist mothers through labor. No epidural analgesia was available. The birth center encouraged family involvement and focused on the emotional and social components of childbirth. Mothers and infants were discharged within 4 to 24 hours after delivery. An evaluation of the newborn and mother was made via a home visit by a nurse within 24 to 48 hours after discharge, and again by the pediatric provider within 5 days. The mother was seen again at the 6-week postpartum visit unless complications or concerns warranted an earlier visit.

Traditional Care

We recruited women receiving perinatal care from 2 hospital-based prenatal care clinics and 7 private physician practices. We selected physician practices on the basis of geographic location, volume of low-income patients, and willingness to participate in the study. Subjects at these sites were managed by obstetricians (20.2% in a hospital clinic and 64.6% in a private practice) or obstetric residents (15.2%) throughout pregnancy and delivery and were delivered in a hospital setting. The hospital sites (which were also referral sites for the birth center program) had 24-hour anesthesia services, regular use of electronic fetal monitoring and intravenous fluids, and neonatal intensive care units (NICUs). Discharge from these sites was generally 12 to 48 hours after a vaginal delivery, with special postpartum follow-up, such as home visits, at the discretion of the provider. CPSP services were available at most sites via physician referral.

Population Description and Sampling Plan

From February 1, 1994, through November 1, 1996, we enrolled 3376 women in the study. Both collaborative care and traditional care subjects were recruited at the beginning of prenatal care and were retained in their initial study group for analysis regardless of eventual delivery site. Because of administrative problems at 1 of the traditional care sites, eligible women from that site were not recruited during prenatal care. Therefore, 361 subjects from this and 1 additional private physician site were added to the traditional care group via retrospective chart review to ensure adequate sample size. The final study sample comprised 3733 subjects (2756 in collaborative care and 1577 in traditional care).

Women with private or military insurance were excluded from the study, because our focus was on low-income women. Also, enrollment in prenatal care at a gestational age of 33 weeks or older was established as an exclusion criterion to correspond with birth center program criteria.

We used existing birth center eligibility criteria to determine study eligibility with regard to perinatal risk. The protocols are too lengthy to list here, but examples of birth center exclusion criteria included 2 or more prior cesarean sections, undocumented uterine scar, chronic hypertension, and substance abuse during pregnancy. Although practitioners were guided by these protocols, clinical judgment remained a factor in eligibility decisions. Therefore, actual birth center providers (i.e., CNMs) were used to classify both collaborative care and traditional care subjects as to birth center eligibility.

For collaborative care subjects, provisional birth center eligibility was determined as part of their initial prenatal visit. For traditional care subjects, our goal was to determine which women would have been birth center eligible if they had presented for care at a collaborative care site. For this determination, CNMs were given information abstracted from the medical record for each traditional care subject and were asked to classify these women as birth center eligible or not birth center eligible at entry into care. Only data collected up to and including the first prenatal visit were included in the review, as was the case for the collaborative care subjects.

Two CNMs reviewed each record. Disagreements between the 2 reviews were referred to a third CNM for a decision. None of the CNMs were aware of the other reviewers' assessments or of how many times a record had been reviewed. This methodology was validated in an earlier study that compared blinded reviewer assessments with actual eligibility determinations made during antenatal care.[13] To monitor continued validity of this procedure, abstract forms from collaborative care women were added in a blinded fashion to CNM reviews on several occasions. The results were consistent with the original validation study (94%–95% agreement).

In addition, a perinatologist familiar with the birth center protocols evaluated the eligibility data for both collaborative care and traditional care subjects. Discrepancies between the reviews by the perinatologist and the CNMs (<10%) were resolved via a conference of the perinatologist and the collaborative care program CNM director and medical director. All reviews were blinded.

Data Collection and Measurement Tools

We collected data on maternal, perinatal, and neonatal mortality and morbidity; antepartum, intrapartum, and postpartum risk factors and complications; sociodemographics; use of resources and procedures; and neonatal outcomes such as birthweight, gestational age, and Apgar scores.[14] We obtained the majority of data from medical records. We measured prenatal care utilization with the Adequacy of Prenatal Care Utilization Index.[15] Women also completed a self-administered questionnaire at entry into the study that inquired about acculturation (with selected items from the Cuellar Acculturation Scale as adapted for the Hispanic Health and Nutrition Examination Survey[16]) and selection of care site. The questionnaire was available in Spanish and English. For retrospective subjects, key questionnaire data were available from the medical records with a reliability of 100% for country of origin and of 85% to 100% for language spoken.

Data Analysis

There were 3 categories of outcomes: maternal, neonatal, and behavioral. Recognizing the low occurrence of major perinatal complications in the low-risk group, we used aggregate variables for serious morbidity. Beginning with available, validated aggregate variables,[1,14] we reviewed each potential risk or complication and evaluated it for (1) potential to contribute to serious morbidity or mortality and (2) comparability of information across study groups. For example, fetal heart rate abnormalities represent a potential for serious morbidity but were measured differently by the birth center (intermittent Doppler auscultation) and the hospital (electronic fetal monitoring). Therefore, this item

was not included in the aggregate variable but was reported separately. Table 1 defines each aggregate variable.

We used risk differences to compare outcomes across the 2 groups, because expected incidences of study outcomes ranged from very low (e.g., perinatal mortality) to very high (e.g., breastfeeding), and risk differences would be influenced less than risk ratios by the magnitude of the compared risks. We used a data-based approach to identify potential confounders for adjusted analyses among baseline demographic characteristics. This approach compares the estimates of effect obtained with and without adjustment for each potential confounder, conditional on other potential confounders, and retains confounders that substantially change the estimate of effect (generally by more than 10%).[17] We retained race/ethnicity a priori in all models because of the differences in this variable across the 2 study groups (Table 2). We used general linear modeling with SAS GENMOD (SAS Institute Inc, Cary, NC) with binomial distribution and identity link function, to produce adjusted risk differences and Wald estimates of 95% confidence intervals (CIs).[18–20]

RESULTS

There were 2156 collaborative care and 1577 traditional care women who met study criteria. After completion of the birth center eligibility review process, 142 (6.6%) of the collaborative care and 232 (14.7%) of the traditional care subjects were deemed not eligible for birth center delivery at entry into prenatal care. No outcome data were available for 7.3% of collaborative care subjects and 9.7% of traditional care subjects. Another 87 subjects had either a spontaneous or a therapeutic abortion, and 38 were diagnosed with multiple pregnancy (a risk factor precluding birth center delivery), leaving 1808 collaborative care and 1149 traditional care subjects available for the analysis.

Crossovers between the 2 study groups were minimal (1.9% for collaborative care vs 1.3% for traditional care). This sample size provided a power of 80% (α=.05) to detect clinically significant risk differences of 3% to 5% for major indicators of interest (cesarean section delivery; major antepartum, major intrapartum, or neonatal complications; NICU admissions).

TABLE 1—Definition of San Diego Birth Center Study Aggregate Variables

- Prior pregnancy risk/major medical risk factor
  - Chronic hypertension
  - Chronic renal disease
  - Diabetes mellitus
  - Heart disease, class II–IV
  - HIV antibody positive
  - Prior pregnancy complications except cesarean section delivery and prior vaginal birth after cesarean section
- Major antepartum morbidity
  - Placenta previa
  - Placental abruption
  - Gestational diabetes
  - Pregnancy-induced hypertension, severe
  - Pregnancy-induced hypertension, with eclampsia
  - Pyelonephritis
  - Intrauterine fetal death
  - Rh sensitization
  - Other (per clinical review)
- Major intrapartum morbidity
  - Cord prolapse
  - Placenta previa
  - Placental abruption
  - Pregnancy-induced hypertension, severe
  - Pregnancy-induced hypertension, with eclampsia
  - Heavy/thick meconium
  - Gestational age < 34 weeks at birth
  - Rupture of uterine scar
  - Hemorrhage ≥ 1000 cubic centimeters
  - Shoulder dystocia
  - Fourth-degree perineal laceration
  - Cervical laceration requiring repair
  - Sulcus laceration requiring repair
  - Intrauterine fetal death
  - Other (per clinical review)
- Major maternal postpartum morbidity
  - Anesthesia complications
  - Disseminated intravascular coagulation
  - Pulmonary embolus
  - Hematoma
  - Pregnancy-induced hypertension, severe
  - Pregnancy-induced hypertension, with eclampsia
  - Maternal death
  - Other (per clinical review)
- Major neonatal morbidity
  - Seizures
  - Asphyxia
  - Bacterial infection other than sepsis

Continued

TABLE 1—*Continued*

- Bronchopulmonary dysplasia
- Cardiac failure
- Hypovolemia, hypotension, shock
- Intraventricular hemorrhage
- Necrotizing enterocolitis
- Persistent pulmonary hypertension
- Pneumonia
- Renal failure
- Respiratory distress syndrome
- Retinopathy of prematurity
- Rh disease
- Sepsis
- Gestational age < 34 weeks at birth
- Other (per clinical review), including palsy or fracture

Baseline characteristics of subjects are presented in Table 2. The 2 groups differed on many demographic characteristics but were similar for prior pregnancy and medical risk, as expected on the basis of overall study risk eligibility criteria.

Table 3 presents maternal outcomes. Despite differences across the groups in demographic characteristics, comparison of crude and adjusted risk differences revealed little confounding except for poor labor progress and cesarean section delivery, which were confounded by parity and cesarean section history.

Major maternal morbidity was similar in the 2 groups at all stages of pregnancy, delivery, and postpartum, except for rates of fetal heart rate abnormalities (Table 3). Use of intrapartum resources and procedures varied across the 2 groups, with more-technical interventions (e.g., oxytocin induction and augmentation, episiotomies, epidural use) being more common in traditional care, and less-technical interventions (e.g., ambulation, tub or shower use, oral fluids) being more common in collaborative care.

Method of delivery differed substantially. Almost 15% more women in collaborative care than in traditional care had normal, spontaneous vaginal deliveries. In addition, 23% fewer women in collaborative care received episiotomies. Women in collaborative

TABLE 2—Baseline Characteristics

	Collaborative Care, No. (%)	Traditional Care, No. (%)	Difference (95% CI)
Maternal age			
<20 years	391 (21.6)	250 (21.8)	-0.1 (-3.2, 2.9)
>35 years	54 (3.0)	53 (4.6)	-1.6 (-3.1, -0.2)
Parity			
Nullipara	808 (44.7)	460 (40.3)	4.7 (1.0, 8.3)
Multipara without history of cesarean section	927 (51.3)	571 (49.7)	1.6 (-2.1, 5.3)
Multipara with history of cesarean section	73 (4.2)	115 (10.0)	-6.0 (-7.9, -4.0)
Marital status			
Single	970 (53.7)	657 (57.2)	-3.5 (-7.2, 0.1)
Married	789 (43.6)	424 (36.9)	6.7 (3.1, 10.3)
Other/unknown	49 (2.7)	68 (5.9)	-3.2 (4.8, -1.7)
Race/ethnicity			
Hispanic	1561 (86.3)	703 (61.2)	25.2 (21.9, 28.4)
White, non-Hispanic	152 (8.4)	233 (20.3)	-11.9 (-14.5, -9.2)
African American	59 (3.3)	141 (12.3)	-9.0 (-11.1, -7.0)
Other/unknown	36 (2.0)	72 (6.3)	-4.3 (-5.8, -2.7)
Country of origin			
Mexico	1344 (74.3)	490 (42.7)	31.7 (28.2, 35.2)
United States	338 (18.7)	538 (46.8)	-28.1 (-31.5, -24.7)
Other/unknown	126 (7.0)	121 (10.5)	-3.6 (-5.7, -1.4)
Language spoken			
Spanish only	979 (55.4)	293 (26.2)	29.2 (25.8, 32.7)
Bilingual (Spanish/English)	562 (31.8)	424 (37.9)	-6.1 (-9.7, -2.5)
English only	200 (11.3)	360 (32.2)	-20.9 (-24.0, -17.8)
Other language	26 (1.5)	42 (3.8)	-2.3 (-3.5, -1.0)
Education			
<9 years	633 (35.1)	169 (14.7)	20.3 (17.3, 23.3)
9–12 years	951 (53.3)	721 (66.6)	-13.3 (-16.9, -9.7)
>12 years	199 (11.0)	192 (16.7)	-5.7 (-8.3, -3.1)
Height[a]			
≤60 inches	458 (26.2)	151 (14.3)	11.9 (9.0, 14.9)
61–67 inches	1250 (71.5)	832 (78.8)	-7.3 (-10.5, -4.0)
≥68 inches	40 (2.3)	73 (6.9)	-4.6 (-6.3, -2.9)
Body mass index[a,b]			
Underweight (<19.8)	180 (11.8)	137 (14.6)	-2.8 (-5.5, 0.0)
Normal weight (19.8–26.1)	908 (59.7)	532 (56.7)	3.0 (-1.0, 7.1)
Overweight (>26.1)	433 (28.5)	270 (28.8)	-0.3 (-4.0, 3.4)
Substance use			
Smoked during pregnancy	94 (5.3)	111 (10.3)	-5.0 (-7.1, -2.9)
History of substance abuse	68 (3.8)	50 (4.7)	-0.9 (-2.4, 0.7)
Used alcohol during pregnancy	55 (3.1)	35 (3.3)	-0.2 (-1.5, 1.1)
Prior pregnancy or medical risk factor[c]	304 (16.9)	186 (16.2)	0.6 (-2.1, 3.4)

Note. CI = confidence interval.
[a]Subjects with missing values not included in denominator.
[b]Categories as defined in *Nutrition During Pregnancy: Part I: Weight Gain, Part II: Nutrient Supplements.*[24]
[c]See Table 1.

care had shorter lengths of stay in the birth facility, with 28% more being discharged before 24 hours, and almost 6% fewer having stays longer than 72 hours. During pregnancy, 9% fewer women in collaborative care than in traditional care made visits to the emergency room, but 63% more used CPSP services.

Overall, neonatal outcomes were similar across the groups (Table 4). The only difference was that traditional care included more sepsis workups (complete blood count; blood, urine, or spinal fluid culture; or chest x-ray) with antibiotic treatment lasting 1 to 3 days. However, sepsis workups without treatment, workups with treatment of 4 to 9 days, and sepsis diagnoses (positive blood culture or treatment of 10 or more days) were similar in the 2 groups. Neonatal readmissions before 28 days and perinatal mortality were also similar. Rates of intrauterine fetal death (>20 weeks) were 0.4% in both groups (risk difference [RD]=0.0; 95% CI=−0.5, 0.4), and rates of early neonatal deaths (0–28 days) were 0.2% in collaborative care versus 0.3% in traditional care (RD=−0.1; 95% CI=−0.5, 0.3).

For behavioral outcomes, slightly fewer collaborative care women than traditional care women initiated prenatal care in the first trimester (37% vs 44%; adjusted RD=−3.0; 95% CI=−7.0, −1.1). Whereas rates of inadequate prenatal care were similar in the 2 groups, there were fewer collaborative care women than traditional care women with intermediate prenatal care utilization (inadequate=32.4% vs 34.7%; adjusted RD=−3.6; 95% CI=−7.4, 0.3; intermediate=6.8% vs 12.1%; adjusted RD=−3.4; 95% CI=−5.9, −1.0). Breastfeeding at discharge was higher in collaborative care than in traditional care (91.8% vs 82.6%; adjusted RD=6.6; 95% CI=3.8, 9.4).

All of these results remained essentially unchanged when we restricted the analyses to Hispanic women to balance racial/ethnic distribution across the groups (data not shown).

DISCUSSION

This study was the first large prospective cohort study of an integrated collaborative management/birth center program that rigor-

TABLE 3—Maternal Medical and Resource Utilization Outcomes[a]

	Collaborative Care, No. (%) (n = 1808)	Traditional Care, No. (%) (n = 1149)	Crude Difference (95% CI)	Adjusted Difference[g] (95% CI)
Morbidity[b]				
Major antepartum complications	104 (5.8)	73 (6.4)	−0.6 (−2.4, 1.2)	−0.5 (−2.5, 1.5)
Major intrapartum complications	329 (19.6)	201 (20.2)	−0.5 (−3.7, 2.6)	0.8 (−2.4, 4.0)
Major postpartum complications	14 (0.8)	4 (0.4)	0.4 (−0.1, 1.0)	0.6 (−4.2, 5.3)
Poor labor progress[c]	570 (32.4)	314 (28.9)	3.5 (0.0, 6.9)	1.4 (−2.1, 4.9)
Fetal heart rate abnormalities[c]	185 (10.5)	210 (19.4)	−8.8 (−11.6, −6.1)	−7.5 (−10.5, −4.4)
Intrapartum maternal febrile morbidity[c]	76 (4.3)	67 (6.2)	−1.9 (−3.6, −0.1)	−2.5 (−5.9, 0.9)
Heavy/thick meconium[c]	84 (4.8)	51 (4.7)	0.1 (−1.5, 1.7)	−0.6 (−3.2, 2.1)
Resource utilization				
oxytocin/prostaglandin induction[c]	149 (8.4)	159 (14.7)	−6.3 (−8.7, −3.8)	−6.0 (−8.7, −3.3)
oxytocin augmentation[c]	279 (15.8)	287 (26.5)	−10.7 (−13.9, −7.6)	−11.2 (−14.5, −7.8)
Amniotomy[c]	925 (53.0)	610 (57.2)	−4.2 (−8.0, −0.4)	−4.6 (−8.8, −0.5)
Epidural anesthesia[c]	522 (29.8)	742 (68.6)	−38.8 (−42.3, −35.3)	−35.7 (−39.5, −31.8)
Narcotic analgesia[c]	512 (29.2)	360 (33.2)	−4.0 (−7.5, −0.5)	−3.4 (−7.1, 0.4)
Ambulation[c]	1063 (74.8)	461 (66.9)	7.9 (3.7, 12.1)	8.1 (3.6, 12.6)
Tub bath/shower[c,d]	531 (37.4)	21 (3.1)	34.3 (31.5, 37.1)	32.1 (27.8, 36.3)
Oral fluids or food[c]	787 (49.8)	102 (10.3)	39.8 (36.7, 42.9)	40.2 (36.8, 43.6)
Intravenous fluids[c,e]	1075 (67.1)	1004 (96.9)	−29.8 (−32.4, −27.3)	−26.6 (−30.4, −22.7)
Continuous electronic fetal monitor[c,e]	854 (48.0)	1027 (94.3)	−46.3 (−49.0, −43.6)	−45.9 (−48.8, −42.9)
Episiotomy[c]	209 (13.1)	348 (37.8)	−24.8 (−28.3, −21.2)	−22.5 (−26.4, −18.5)
Method of delivery				
Normal spontaneous vaginal	1462 (80.9)	720 (62.8)	18.0 (14.8, 21.5)	14.9 (11.5, 18.3)
Assisted vaginal	151 (8.4)	208 (18.1)	−9.8 (−12.3, −7.2)	−9.7 (−12.5, −6.9)
Cesarean section	194 (10.7)	219 (19.1)	−8.4 (−11.0, −5.7)	−4.7 (−7.3, −2.2)
Maternal length of stay[f]				
< 24 hours	791 (44.2)	132 (11.6)	32.6 (29.7, 35.6)	27.5 (23.9, 31.2)
24–48 hours	626 (35.0)	625 (54.9)	−19.9 (−23.5, −16.3)	−20.3 (−24.3, −16.4)
> 48–72 hours	187 (10.5)	199 (17.5)	−7.0 (−9.7, −4.4)	−5.2 (−8.1, −2.3)
> 72 hours	184 (10.3)	182 (16.0)	−5.7 (−8.3, −3.1)	−5.8 (−8.6, −3.1)
Nondelivery admissions and emergency room				
Antepartum hospital admission	52 (2.9)	65 (5.7)	−2.8 (−4.3, −1.2)	−2.1 (−5.2, 1.1)
Emergency room without admission	445 (24.6)	394 (34.4)	−9.8 (−13.2, −6.4)	−9.0 (−12.8, −5.2)
Postpartum maternal readmission	8 (0.4)	11 (1.0)	−0.5 (−1.2, 0.1)	−0.9 (−4.8, 3.0)
Use of Comprehensive Perinatal Services Program	1729 (95.6)	376 (32.7)	62.9 (6.0, 6.6)	55.6 (51.9, 59.3)

Note. CI = confidence interval.
[a]Missing data not included.
[b]Aggregate complication variables: major antepartum complications, major intrapartum complications, major maternal postpartum complications (see Table 1).
[c]Does not include women admitted directly for cesarean section without labor (collaborative care = 1779; traditional care = 1089).
[d]Adjusted for race/ethnicity, education, and country of origin.
[e]Adjusted for race/ethnicity, education, age, marital status, country of origin, height, and smoking during pregnancy.
[f]Total length of stay from admission to discharge.
[g]Adjusted for race/ethnicity, parity and cesarean section history, education, age, marital status, country of origin, height, and smoking during pregnancy, except where otherwise specified.

ously balanced initial perinatal risk across the collaborative care and traditional care groups. Our findings indicate that such a program is safe and that use of resources and procedures, such as operative deliveries and hospital stays, is substantially reduced with collaborative care compared with the traditional US model of perinatal care. Because these resources and procedures are major determinants of the cost of perinatal care, managed care organizations, local and state governments, and obstetric providers should consider inclusion of collaborative management/birth center programs in their array of covered or offered services. Because our study examined outcomes in a large cohort of low-risk women from the time they began prenatal care, rather than only that subgroup that

TABLE 4—Neonatal Medical and Resource Utilization Outcomes[a]

	Collaborative Care, No. (%) (n = 1794)	Traditional Care, No. (%) (n = 1141)	Crude Difference (95% CI)	Adjusted Difference[d] (95% CI)
Neonatal medical outcomes				
Morbidity				
Major neonatal complications[b]	80 (4.5)	73 (6.4)	−1.9 (−3.6, −0.2)	−1.8 (−3.8, 0.1)
Apgar score under 7 at 5 minutes	15 (0.8)	5 (0.4)	0.4 (−0.2, 1.0)	0.9 (−3.7, 5.4)
Preterm delivery				
< 37 weeks	114 (6.4)	74 (6.5)	−0.1 (−2.0, 1.7)	0.2 (−1.7, 2.1)
< 34 weeks	22 (1.2)	21 (1.8)	−0.6 (−1.5, 0.3)	−0.5 (−3.4, 2.5)
Birthweight				
< 2500 grams	69 (3.8)	46 (4.0)	−0.2 (−1.6, 1.3)	0.5 (−1.7, 2.7)
< 1500 grams	9 (0.5)	7 (0.6)	−0.1 (−0.7, 0.4)	−0.2 (−5.6, 5.2)
Small for gestational age[c]	104 (5.9)	50 (4.5)	1.4 (−0.2, 3.0)	1.7 (−1.5, 4.8)
Large for gestational age[c]	154 (8.7)	108 (9.7)	−1.0 (−3.1, 1.2)	−0.5 (−2.9, 1.9)
Resource utilization				
Neonatal intensive care unit admission				
Any	171 (9.7)	134 (11.8)	−2.2 (−4.5, 0.1)	−1.3 (−3.8, 1.1)
1–3 days	60 (3.3)	64 (5.6)	−2.3 (−3.9, −0.7)	−1.8 (−3.9, 0.2)
4–10 days	81 (4.6)	52 (4.6)	0.0 (−1.6, 1.5)	0.0 (−1.8, 1.9)
> 10 days	30 (1.7)	18 (1.6)	0.1 (−0.8, 1.0)	0.1 (−2.6, 2.4)
Positive pressure ventilation				
At delivery	94 (5.3)	71 (6.3)	−1.0 (−2.8, 0.8)	−0.5 (−2.4, 1.4)
> 1 day	17 (1.0)	9 (0.8)	0.2 (−0.5, 0.8)	0.6 (−2.7, 3.8)
Sepsis work-up and treatment				
Workup without treatment	78 (4.4)	67 (5.6)	−1.5 (−3.2, 0.1)	−0.6 (−2.3, 1.2)
Workup with treatment of 1–3 days	33 (1.8)	61 (5.4)	−3.4 (−5.0, −2.1)	−3.8 (−6.4, −1.3)
Workup with treatment of 4–9 days	60 (3.3)	38 (3.3)	0.0 (−1.3, 1.3)	−0.1 (−2.7, 2.5)
Sepsis (positive culture or treatment (10 days)	11 (0.6)	6 (0.5)	0.1 (−0.5, 0.6)	0.0 (−3.6, 3.6)
Neonatal readmission (< 28 days of age)	25 (1.4)	25 (2.2)	−0.8 (−1.8, 0.2)	−1.3 (−4.1, 1.5)

Note. CI = confidence interval.
[a]Among live births; missing data not included.
[b]See Table 1.
[c]As defined by Williams et al.[25]
[d]Adjusted for race/ethnicity, parity and cesarean section history, education, age, marital status, country of origin, height, and smoking during pregnancy.

ultimately delivered in a freestanding facility, our data also provide information to assist health program administrators as they consider the impact of offering a program of collaborative care and freestanding birth center delivery to a broader population of women.

Lieberman and Ryan[8] and the Committee on Assessing Alternative Birth Settings[21] noted the limited possibilities for conducting a randomized trial of alternative birth settings. One risk in nonrandomized studies is potential confounding. After implementing extensive procedures to assess birth center eligibility at entry into prenatal care for women in both groups, we found that although the 2 care groups differed in demographic characteristics, adjustment for these differences did not materially affect estimates of study outcomes. In addition, as an alternative strategy to address potential confounding attributable to differences in race/ethnicity, we reanalyzed the results after restricting the sample to Hispanic women (the majority group in both cohorts). The results and inferences were materially unaltered. Therefore, we included all racial/ethnic groups in this report to maximize the precision of the estimates and continued to retain race/ethnicity a priori in all statistical models. Although potential residual confounding or confounding by unknown perinatal risk factors may exist, these forces would have to be quite large to provide a credible alternative explanation of our results.

In addition to concerns about baseline perinatal risk, we also considered the problem of selection bias[9,21]—that is, that women who selected collaborative care might be healthier, in ways not measured by the birth center eligibility criteria, than women who selected traditional care. We included an item about selection of care sites in the questionnaire. When we analyzed data for women in the collaborative care group who indicated that they had specifically sought midwifery care or

a birth center delivery, we found their demographics, risk factors, and outcomes to be no different from those of women who selected their care site for other reasons, such as location of the clinic or financial considerations.

These results are consistent with those from a study by Scupholme and Kamons[5] that compared outcomes of women who independently selected a freestanding birth center with those of women who were assigned to delivery in the same facility. They found outcomes between the 2 groups to be similar, which suggests that no selection bias existed and that selection factors focused on care provider or site of care would be unlikely to account for our results.

In a related study, Oakley et al.[22] found that preferences for certain obstetric procedures, such as electronic fetal monitoring and epidural anesthesia, confounded the effect of care provider on method of delivery. Our study did not gather data on a priori preferences for certain procedures. However, the majority (88%) of subjects in both groups selected care on the basis of factors other than provider or birth facility. In this group of low-income women, choices were made according to issues such as recommendations from friends or family (24%), friendly staff (21%), previous care at the site (10%), location of the service site (9%), bilingual staff (6%), and financial considerations (3%).

The study relied primarily on medical record abstraction, which carries the potential for missing or inadequate data.[9] Key study variables were available from the records at more than 90% of all sites. Because of administrative difficulties at 1 traditional care site, and to increase the sample size, data for 26% of the traditional care group were collected only from medical records. Birth center eligibility rates for these 2 subgroups of traditional care subjects were similar (83% for those with medical record and questionnaire data vs 86% for those with only medical record data).

Although many factors potentially could have contributed to the observed differences in method of delivery observed in our study, 2 particular potential contributors varied across the care groups: (1) differences in provider response to particular diagnoses and (2) different methods of monitoring. An example of diagnosis-associated differences is that women diagnosed with poor labor progress in the collaborative care group had a combined assisted/cesarean section delivery rate of 42.8%, compared with a rate of 62.7% for women with the same diagnosis in the traditional care group (adjusted RD= −21.4%; 95% CI=−28.5, −14.2), without an increase in NICU admissions (15.9% collaborative vs 12.8% traditional; adjusted RD= 2.2%; 95% CI=−3.9, 8.3), low 5-minute Apgar scores (1.4% vs 0.3%; adjusted RD= 1.0%; 95% CI=−12.4, 14.5), or major maternal (29.2% vs 33.6%; adjusted RD= −2.5%; 95% CI=−10.4, 5.5) or neonatal (7.6% vs 6.4%; adjusted RD=0.6%; 95% CI=−6.5, 7.6) complications.

An example of monitoring method–associated differences is that the use of electronic fetal monitoring (vs intermittent Doppler auscultation) has been linked to more-frequent cesarean section delivery owing to the increased diagnosis of fetal heart rate abnormalities associated with electronic monitoring.[23] In our study, women diagnosed with fetal heart rate abnormalities (11% in collaborative care and 19% in traditional care) had cesarean section delivery rates of 31% and 30%, respectively (adjusted RD= 0.7%; 95% CI=−8.7, 10.1), indicating that the response to the diagnosis of fetal heart rate abnormalities were essentially the same in both groups, but that the rate of fetal heart rate abnormalities diagnosed in the 2 groups were different, likely owing to monitoring type. This differential in diagnosis of fetal heart rate abnormalities did not appear to adversely affect neonatal outcomes (Table 4).

Our study suggests that the collaborative care model, with birth center delivery for women who remain at low risk, and the traditional physician-based perinatal care model are different health care service routes to a common end point: safe outcomes for mothers and infants. But our study also indicates that these 2 models are associated with substantially different levels of use of medical resources and procedures. ■

About the Authors

At the time of the study, Debra J. Jackson was with The BirthPlace Research Department, San Diego, Calif. William H. Swartz and Theodore G. Ganiats were with the University of California, San Diego, School of Medicine. Judith Fullerton was with the University of Texas at El Paso School of Nursing. Jeffrey Ecker was with Harvard Medical School and Massachusetts General Hospital, Boston. Janet M. Lang and Uyensa Nguyen were with the Boston University School of Public Health, Boston, Mass.

Requests for reprints should be sent to Debra J. Jackson, RN, MPH, DSc, University of the Western Cape, School of Public Health, PO Box 16239, Vlaeberg, Cape Town, South Africa 8018 (e-mail: bessrfam@iafrica.com).

This article was accepted September 18, 2002.

Contributors

D.J. Jackson designed the study, supervised data collection and data entry, and was the primary author of the article. J.M. Lang designed the study and supervised data analysis. W.H. Swartz was the principal investigator and contributed to study design and interpretation of data. T.G. Ganiats contributed to study design and provided expertise in outcomes analysis. J. Fullerton contributed to study design, provided expertise in midwifery, and supervised data quality assurance. J. Ecker conducted eligibility assessments. U. Nguyen conducted data analysis. All authors contributed to the writing of the article, including review of all revisions.

Acknowledgments

This project was funded by US Agency for Healthcare Research and Quality grant R01-HS07161. Institutional support was also received from Sharp HealthCare of San Diego and athenahealth of Boston.

The authors would like to thank the project staff and consultants for their contributions, and also the physicians, nurse–midwives, clinic office staff, and women who participated in this study.

Human Participant Protection

Institutional review board approval was secured for this project at all participating institutions, and informed consent for study participation was obtained from all prospective cohort subjects.

References

1. Rooks JP, Weatherby NL, Ernst EK, Stapleton S, Rosen D, Rosenfield A. Outcomes of care in birth centers. The National Birth Center Study. *N Engl J Med.* 1989;321:1804–1811.

2. Baruffi G, Dellinger WS Jr, Stobino DM, Rudolph A, Timmons RY, Ross A. A study of pregnancy outcomes in a maternity center and a tertiary care hospital. *Am J Public Health.* 1984;74:973–978.

3. Feldman E, Hurst M. Outcomes and procedures in low risk birth: comparison of hospital and birth center settings. *Birth.* 1987;14:18–24.

4. Scupholme A, McLeod AG, Robertson EG. A birth center affiliated with the tertiary care center: comparison of outcome. *Obstet Gynecol.* 1986;67: 598–603.

5. Scupholme A, Kamons AS. Are outcomes compromised when mothers are assigned to birth centers for care? *J Nurse Midwifery.* 1987;32:211–215.

6. Spellacy W. The Delivery Center: a modified hospital plan to reduce obstetric costs. *J Perinatol.* 1985;5:1.

7. Garite TJ, Snell BJ, Walker DL, Darrow VC. Development and experience of a university-based, freestanding birthing center. *Obstet Gynecol.* 1995;86:411–416.

8. Lieberman E, Ryan KJ. Birthday choices. *N Engl J Med.* 1989;321:1824–1825.

9. Albers LL, Katz VL. Birth setting for low-risk pregnancies. An analysis of the current literature. *J Nurse Midwifery.* 1991;36:215–220.

10. Dickinson CP, Jackson DJ, Swartz WH. Making the alternative the mainstream. Maintaining a family-centered focus in a large freestanding birth center for low-income women. *J Nurse Midwifery.* 1994;39:112–118.

11. California Dept of Health Services. *Final Evaluation of the Obstetrical Access Pilot Project, July 1979 to June 1982.* Sacramento, Calif: Dept of Health Services, Maternal and Child Health Branch; 1984.

12. National Association of Childbearing Centers. *Quality Assurance Guidelines.* Perkiomenville, Penn: National Association of Childbearing Centers; 1992.

13. Jackson DJ, Lang JM, Dickinson CP, Fullerton JT. Use of the nurse-midwifery clinical data set for classification of subjects in birth center research. *J Nurse Midwifery.* 1994;39:197–213.

14. Greener D. Development and validation of the Nurse-Midwifery Clinical Data Set. *J Nurse Midwifery.* 1991;36:174–183.

15. Kotelchuck M. An evaluation of the Kessner Adequacy of Prenatal Care Index and a proposed Adequacy of Prenatal Care Utilization Index. *Am J Public Health.* 1994;84:1414–1420.

16. National Center for Health Statistics. Plan and operation of the Hispanic Health and Nutrition Examination Survey, 1982–84. *Vital Health Stat 1.* 1985;No. 19.

17. Rothman KJ, Greenland S. *Modern Epidemiology.* 2nd ed. Philadelphia, Penn: Lippincott Williams & Wilkins; 1998.

18. Wacholder S. Binomial regression in GLIM: estimating risk ratios and risk differences. *Am J Epidemiol.* 1986;123:174–184.

19. Wallenstein S, Bodian C. Epidemiologic programs for computers and calculators. Inferences on odds ratios, relative risks, and risk differences based on standard regression programs. *Am J Epidemiol.* 1987;126:346–355.

20. SAS Institute. *SAS/STAT Software: Changes and Enhancements Through Release 6.11.* Cary, NC: SAS Institute; 1996.

21. Committee on Assessing Alternative Birth Settings, Institute of Medicine. *Research Issues in the Assessment of Birth Settings: Report of a Study.* Washington, DC: National Academy Press; 1982.

22. Oakley D, Murray ME, Murtland T, et al. Comparisons of outcomes of maternity care by obstetricians and certified nurse-midwives. *Obstet Gynecol.* 1996;88:823–829.

23. American College of Obstetricians and Gynecologists. *Fetal Heart Rate Patterns: Monitoring, Interpretation, and Management.* Washington, DC: American College of Obstetricians and Gynecologists; July 1995. ACOG Technical Bulletin No. 207.

24. Institute of Medicine. *Nutrition During Pregnancy: Part I: Weight Gain, Part II: Nutrient Supplements.* Washington, DC: National Academy Press; 1990.

25. Williams RL, Creasy RK, Cunningham GC, Hawes WE, Norris FD, Tashiro M. Fetal growth and perinatal viability in California. *Obstet Gynecol.* 1982;59:624–632.