Increasing VLBW Deliveries at Subspecialty Perinatal Centers via Perinatal Outreach

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KEY WORDS

perinatal mortality, perinatal morbidity, Healthy People 2010 objective, VLBW, very low birth weight, levels of care, perinatal outreach

ABBREVIATIONS

SPC—subspecialty perinatal center

VLBW—very low birth weight

ICH—intracranial hemorrhage

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WHAT'S KNOWN ON THIS SUBJECT: The American Academy of Pediatrics Guidelines for Perinatal Care recommends delivery of infants <32 weeks' gestation at subspecialty perinatal centers (SPCs). Infants born with very low birth weights (VLBW) at SPCs have decreased perinatal morbidity and mortality.

WHAT THIS STUDY ADDS: Perinatal outreach education to providers at non-SPCs is an effective strategy to promote transfer of all pregnant mothers with <32 weeks' gestation to SPCs for delivery. The Healthy People 2010 objective to deliver 90% of infants born with VLBW in SPCs is achievable.

abstract

OBJECTIVES: To test the hypothesis that the promotion of national guidelines recommending the transfer of high-risk mothers to subspecialty perinatal centers reduces mortality and morbidity through the reduction of preterm infants delivered at nontertiary maternity hospitals.

METHODS: After implementation of hospital-based educational and communication programs emphasizing the importance of maternal transfer to subspecialty perinatal centers, we conducted a population-based cohort study of all live births delivered at maternity hospitals in greater Cincinnati from 2003 through 2007 ($n = 1825$). Birth weights measured between 500 and 1499 g and gestational ages were less than 32 weeks. Risk-adjusted outcomes were measured by multivariate logistic regression in 2 stages. We compared these findings with those from a similar study conducted at our institution that included infants with birth weights less than 1500 g born between September 1, 1995, and December 31, 1997 ($n = 848$). The primary outcome was the percentage decrease in infants born with very low birth weights at nontertiary centers compared with our previous study.

RESULTS: The number of infants born with birth weights less than 1500 g and at less than 32 weeks' gestation delivered at hospitals without tertiary perinatal and neonatal care decreased from 25% to 11.8% between the 2 study periods. The odds of death or major morbidity for infants born with very low birth weights at nontertiary perinatal centers is 3 times that of infants born at subspecialty perinatal centers after controlling for demographic variations (odds ratio: 3.05 [95% confidence interval: 2.1–4.4]).

CONCLUSIONS: Local promotion of national guidelines by neonatologists coincided with a significant reduction in the percentage of infants born with birth weights less than 1500 g and at less than 32 weeks' gestation who were not delivered at subspecialty perinatal centers, and, at 88.2%, this nearly achieves the Healthy People 2010 objective to deliver 90% of infants born with very low birth weights in subspecialty perinatal centers. *Pediatrics* 2011;127:487–493

The American Academy of Pediatrics and the American College of Obstetrics and Gynecologists Guidelines for Perinatal Care recommend that hospital-based services be organized within geographical regions and delivery hospitals designated as levels 1 (basic), 2 (specialty), and 3 (subspecialty) on the basis of functional capabilities to provide comprehensive care for high-risk pregnant women and neonates.^{1,2} These guidelines recommend delivery of all infants of less than 32 weeks' gestation at subspecialty perinatal centers (SPCs) to minimize neonatal morbidity and mortality associated with interhospital neonatal transport. These recommendations provide the basis for the United States Public Health Service/Department of Health and Social Services Healthy People 2010 perinatal objectives to deliver 90% of very-low-birth weight (VLBW) (<1500 g) infants at an SPC.³ The clinical guidelines have been in place for more than 2 decades, with variable adherence.

Maternity hospitals in the greater Cincinnati region follow a well-established model of regionalization, with a single neonatal-perinatal medicine program providing care for high-risk infants, neonatal transport, outreach education, research, and quality improvement, covering ~31 000 deliveries per year. Two SPCs provide high-risk maternal-fetal medicine services and house level 3 NICUs for inborn patients. An additional level 3 NICU serves a largely outborn population and cares for all regional neonates requiring complex medical and surgical subspecialty care. This freestanding children's hospital NICU also cares for outborn VLBW preterm neonates. The Division of Neonatology at the Cincinnati Children's Hospital and Medical Center includes 30 neonatologists and maintains close working relationships with maternity providers in the region

through daily clinical practice and regularly scheduled outreach programs.

We previously analyzed regional, population-based data and demonstrated excess mortality and morbidity for VLBW infants born at nonsubspecialty centers.⁴ These findings prompted us to engage all regional maternity centers in an improvement initiative to reduce the incidence of VLBW preterm neonates born at non-SPCs through promotion of maternal transfer to either of the 2 regional SPCs. Our current study tested the hypothesis that the risk-adjusted predischarge morbidity and mortality of infants born at tertiary perinatal centers is less than those born at non-SPCs and evaluated the effect of our perinatal outreach program on the prevalence of VLBW deliveries at nontertiary centers in our region after our previous publication.

METHODS

In a population-based retrospective cohort study design of all live births, with birth weights more than 499 g and less than 1500 g and at less than 32 weeks' gestation born in the greater Cincinnati region between January 1, 2003, and December 31, 2007, demographic and clinical information was reviewed for each birth by direct chart review. Institutional review boards at each of the 18 participating hospitals approved the study. Infants weighing less than 500 g and those with lethal malformations (aneuploidy and congenital malformations) were excluded to focus on infants for whom medical interventions would have an impact on outcomes.

The greater Cincinnati region includes 17 maternity hospitals and 1 freestanding children's hospital located in 13 contiguous counties in southwest Ohio, southeast Indiana, and northern Kentucky. These hospitals include 2 SPCs with onsite tertiary NICUs and

comprehensive high-risk maternal-fetal medicine services. A third NICU is located at the freestanding children's hospital and provides coordination of regional perinatal services through the Cincinnati Perinatal Outreach Program. Mothers with high-risk pregnancies and infants who required tertiary neonatal care were referred from 15 other non-SPCs to 1 of these 3 facilities. Some of the non-SPC hospitals used continuous positive-airway pressure and surfactant therapy for infants with mild to moderate respiratory distress, but none provided long-term mechanical ventilation. For comparisons of the outcomes, infants were assigned to their hospital of birth rather than location of care.

In late 2002, we implemented a strategy to reduce the incidence of preterm birth before 32 weeks occurring at non-SPCs in our region. Our approach focused on hospital maternity departments. Nursing leaders at each non-SPC were provided with information regarding opportunities to reduce morbidity and death by proactive transfer of mothers presenting in active labor before 32 weeks' gestation. If the maternity unit nurse and obstetrician could not agree about the suitability of a maternal transfer, a Division of Neonatology physician provided consultation and regional perinatal outcome data. Obstetricians remained free to make ultimate maternal transfer decisions. Maternal and neonatal definitions used are listed in Table 1.

A composite outcome of death or major morbidity was chosen as the primary outcome to account for possible trade-offs between death and major morbidity. Secondary outcomes included death alone and death in combination with each morbidity (bronchopulmonary dysplasia, intracranial hemorrhage, retinopathy of prematurity, or necrotizing enterocolitis). Risk-adjusted, predischarge major mor-

TABLE 1 Maternal and Neonatal Definitions

Gestational Age	Best Obstetric Estimate
Maternal hypertension or preeclampsia	Maternal blood pressure >140 mm Hg systolic or >90 mm Hg diastolic with or without edema and proteinuria
Maternal diabetes	Diet or insulin use to control blood glucose levels
Antenatal glucocorticoid	Receipt of betamethasone or dexamethasone before delivery
Intrapartum antibiotics	Antibiotic administration to mother during admission that resulted in delivery
Prenatal care	At least 1 prenatal care visit to the obstetrician
Neonatal mortality	Death of a live-born infant before hospital discharge or age 120 d
Live born	Taking a breath or showing any other evidence of life such as heart beat or voluntary movement
Fetal death or still born	Death prior to complete expulsion or extraction from the mother of the products of conception
Bronchopulmonary dysplasia	Receipt of supplemental oxygen at 36 wk' postmenstrual age
Intracranial hemorrhage	Grade 3 or 4 intracranial hemorrhage of Papile classification ¹⁷
Severe retinopathy of prematurity	Receipt of laser or cryotherapy for treatment of ROP
Severe necrotizing enterocolitis	Bell's stage 2 or worse ¹⁸

bidity included bronchopulmonary dysplasia, severe intracranial hemorrhage, severe retinopathy of prematurity, and severe necrotizing enterocolitis, as defined previously (Table 1). Confounding variables included both infant and maternal factors unrelated to care provided by clinicians and practice variables related to clinical decision making. The infant and maternal variables were gestational age, birth weight, race, gender, multiple gestation, 5-minute Apgar score, maternal hypertension or preeclampsia, and maternal diabetes. Practice variables included the Clinical Risk Index for Babies score, use of antenatal glucocorticoids, and use of intrapartum antibiotics. We evaluated the practice variables separately to identify modifiable practices that would help improve outcomes. Disease severity was assessed with the Clinical Risk Index for Babies scores based on information from medical records within the first 12 hours of life. Scores increase with increasing clinical risks.⁵

Data Sources

Data for regional births were obtained retrospectively from 4 sources: (1) the Eunice Kennedy Shriver National Institute of Child Health and Human Development Neonatal Research Network Registry; (2) the Cincinnati Regional

Perinatal Database; (3) the Ohio Department of Health; and (4) the individual hospital-based records. The Eunice Kennedy Shriver National Institute of Child Health and Human Development Network Registry contained demographic and clinical data on all VLBW infants who were cared for in the SPCs. The Regional Perinatal Database is a population-based, perinatal data collection system in which all regional birth hospitals provide aggregate monthly reports of all live births and neonatal deaths by race, birth weight, and presence or absence of lethal malformations. Information about maternal education and insurance status were abstracted from birth certificates. Hospital-based data were obtained on VLBW infants born and cared for at non-SPCs by reviewing individual medical records and maternity-unit log books that record all live and still births. Maternal cervical dilation at presentation and components of the Clinical Risk Index for Babies score also were obtained from the hospital-based records.

Thirty-three VLBW infants reported in the Regional Perinatal Database during the study period were not found to be live births in the hospital-based records and were therefore not included in the analyses. Discrepancies

were because of fetal deaths or still births reported as live births, multiple entries for the same infant, and apparent errors in reporting birth weights in the Regional Perinatal Database. Exclusion of these infants may have created a bias toward the null, away from any significant finding. Forty-eight VLBW infants identified in the hospital-based records, but not found in the Regional Perinatal Database, were included in the analysis. These discrepancies included infants who were transferred from the birth hospital delivery room to an institution with a higher level of care or infants who died in the delivery room and were inadvertently excluded from regional reporting data.

Cervical Dilation Data

Maternal transfer to an SPC can only be accomplished if mothers are candidates for transport at the time of presentation to non-SPCs. Typically, mothers with advanced (>4 cm) or rapidly progressing cervical dilatation are not considered eligible for transfer. We collected data on cervical dilation, hospital admission, and delivery times and dates from labor-and-delivery assessment forms maintained for each mother in her medical record on admission to each maternity hospital.

Statistical Analysis

Regional birth and death rates for infants weighing more than 500 g in the greater Cincinnati region (SPC and non-SPC hospitals) were calculated during the study period. Risk-adjusted effects of birth hospital type (SPC versus non-SPC) on VLBW infant outcomes were evaluated using multivariable logistic regression in 2 stages. In the first stage, effect of birth hospital was controlled only for demographic and maternal variables. The second stage controlled for demographics, maternal/infant variables, and practice variables, such as the Clinical Risk Index for Babies score and use of

TABLE 2 Unadjusted Neonatal Outcomes by Location of Birth

Death	All Non-SPC (<i>n</i> = 216), <i>n</i> (%)	SPC (<i>n</i> = 1609) <i>n</i> (%)
500–749 g	34 (73.9)	139 (50.0) ^a
750–999 g	25 (44.6)	109 (23.5) ^a
1000–1249 g	5 (10.0)	41 (10.3)
1250–1499 g	4 (6.3)	5 (1.1) ^b
500–1499 g	68 (31.5)	294 (18.3) ^c
Morbidity 500–1499 g		
Bronchopulmonary dysplasia	41 (19.0)	286 (17.8)
Grade III/IV intracranial hemorrhage	29 (13.4)	39 (2.4) ^c
Treated retinopathy of prematurity	13 (6.0)	58 (3.6)
Necrotizing enterocolitis	16 (7.4)	160 (9.9)

^a *P* < .01 SPC vs all non-SPCs.^b *P* < .05 Fisher's exact.^c *P* < .0001.

antenatal glucocorticoids and intrapartum antibiotics.

Potential confounders were chosen according to what was statistically significant in the regression models and were considered clinically meaningful. Variables chosen for the models listed in Table 2 were selected using stepwise regression with significance entry criteria set at $\alpha = 0.2$. Variables remained in the models if the adjusted *P* values remained $\leq .10$. Because death was part of the composite outcomes for each of the morbidities listed, we wanted the variables to remain consistent across all models.

Comparisons between non-SPCs and SPCs were made regarding continuous variables using the *t* test for independent samples and χ^2 for categorical variables. A Fisher's exact test was reported, as appropriate, when the expected number of observations in a particular cell was less than 5. Data were analyzed using SAS version 9.2 (SAS Institute, Inc, Cary, NC).

RESULTS

In late 2002, we implemented an ongoing regional communication and educational intervention for non-SPC obstetrical providers and maternity nursing personnel to promote the transfer of mothers presenting in labor before 32 weeks' gestation to an SPC in accordance with established American Academy of Pediatrics and American College

of Obstetricians and Gynecologists guidelines. Data collection was initiated on January 1, 2003. Between January 1, 2003, and December 31, 2007, there were 153 980 live births in the greater Cincinnati region, including 1825 VLBW infants (birth weight: 500–1499 g and gestational age: <32 weeks) accounting for 1.2% of total births. The proportion of all VLBW births that occurred at non-SPCs was 11.8% (*n* = 216) throughout the

study period. This compares with 25% in our previously published study.⁴ Seventy-four percent of infants born at non-SPCs were subsequently transported to 1 of the regional SPCs (Table 3). The larger birth-weight (1250–1499 g) and the smallest birth-weight (500–749 g) cohorts were transferred the least (63% and 61%, respectively). All nontransported infants between 500 and 749 g died within 10 hours of delivery at a non-SPC. There were 360 (20%) deaths among infants 500 to 1499 g. One hundred and eight infants with lethal malformations were excluded from the analyses.

Demographic Characteristics and Neonatal Outcomes

Maternal and infant demographic characteristics are summarized in Table 4. Unadjusted neonatal outcomes reveal greater mortality rates for infants born at non-SPCs for all weight category.

TABLE 3 Regional and Nonspecialty Perinatal Center VLBW Births and Transfers From Non-SPCs From January 1, 2003, Through December 31, 2007, in the Greater Cincinnati Region

Birth Weight	Total, <i>n</i>	Non-SPC, <i>n</i> (%) ^a	SPC, <i>n</i> (%) ^a	Infant Transfers From Non-SPCs, <i>n</i> (%) ^{b,c}
500–749	324	46 (14.2)	278 (85.8)	28 (61)
750–999	520	56 (10.8)	464 (89.2)	47 (84)
1000–1249	447	50 (11.2)	397 (88.8)	44 (88)
1250–1499	534	64 (12)	470 (88.0)	40 (63)
500–1499	1825	216 (11.8)	1609 (88.2)	159 (74)

^a Percentage of total regional births within each birth weight category.^b All non-SPC transfers were to 1 of the 3 SPCs, with the exception of 1 transfer to a SPC in a different city.^c Percentage of infants who were born at a non-SPC and subsequently transported to 1 of the 3 SPCs**TABLE 4** Demographics and Clinical Characteristics of Infants 500 g to 1499 g and <32 Weeks Gestation by Location of Birth

Infant Variables	Non-SPC (<i>n</i> = 216)	SPC (<i>n</i> = 1609)
Birth weight, means (SD), g	1038 (293)	1041 (276)
Gestational, means (SD), age/wk	27.4 (2.6)	27.7 (2.3)
White, <i>n</i> (%)	168 (77.8)	843 (52.4) ^a
Male, <i>n</i> (%)	106 (49.1)	788 (49.0)
Multiple gestation, <i>n</i> (%)	27 (12.5)	299 (18.6) ^b
Apgar score at 5 min <5, <i>n</i> (%)	50 (23.2)	296 (18.4)
Mode of delivery, % cesarean section	119 (55.1%)	1105 (68.7%) ^a
Maternal hypertension/preeclampsia, <i>n</i> (%)	29 (13.4)	271 (16.8)
Maternal diabetes, <i>n</i> (%)	7 (3.2)	45 (2.8)
Antenatal steroids, <i>n</i> (%)	75 (34.7)	1531 (95.2) ^a
Ante-/intrapartum antibiotics, <i>n</i> (%)	164 (75.9)	1049 (65.2) ^b
Clinical Risk Index for Babies score, means (SD)	4.1 (4)	2.5 (2.9) ^a

Continuous variables reported as means (SD) and categorical variables reported as *n* (%).^a *P* < .0001.^b *P* < .05.

TABLE 5 Risk-Adjusted Mortality and Major Morbidity for Infants Born At Non-SPCs versus SPCs by Birth Weight Category

	500–1499 g, <i>n</i> = 1825		500–999 g, <i>n</i> = 844		1000–1499 g, <i>n</i> = 981	
	Adjusted Odds Ratio	Confidence Interval	Adjusted Odds Ratio	Confidence Interval	Adjusted Odds Ratio	Confidence Interval
Death/major morbidity	3.05	2.12–4.39	3.86	2.21–6.76	2.82	1.67–4.76
Mortality	2.11	1.44–3.10	2.41	1.49–3.90	1.67	0.78–3.56
Bronchopulmonary dysplasia or death	1.83	1.27–2.65	2.93	1.66–5.19	1.28	0.72–2.27
Intracranial hemorrhage or death	3.51	2.42–5.10	3.44	2.09–5.68	4.30	2.39–7.76
Retinopathy of prematurity or death	2.24	1.54–3.26	2.56	1.55–4.21	2.08	1.08–4.00
Necrotizing enterocolitis or death	2.14	1.49–3.07	2.69	1.66–4.37	1.53	0.80–2.90

All models controlled for gestational age, small for gestational age, gender, race, and multiple gestation.

ries except infants with birth weights between 1000 and 1249 g. In particular, infants weighing less than 1000 g were more vulnerable and had a significantly increased mortality when born at non-SPCs. In addition, the rate of severe intracranial hemorrhage was significantly increased in VLBW infants delivered in non-SPCs (Table 2).

Site of Delivery and Adverse Outcomes

In regression models using only demographics and infant and maternal variables, the odds of death or any major morbidity for VLBW infants born at non-SPCs was 3.05 times greater than for those born at SPCs (Table 5). The odds of death or any major morbidity significantly decreased with increasing birth weight.

The odds of adverse secondary outcomes were increased two- to three-fold for VLBW infants born at non-SPCs compared with SPCs (Table 5). Similar to mortality, the odds of morbidity were higher for infants weighing 500 to 999 g compared with infants weighing 1000 to 1499 g, except for intracranial hemorrhage or death.

In models that included demographics

and infant, maternal, and practice variables, birth in a non-SPC increased the odds of death or any major morbidity. The odds of death or major morbidity along with secondary outcomes remained fairly high after the addition of acuity scores (Clinical Risk Index for Babies) but became nonsignificant after the addition of antenatal glucocorticoids and antibiotics. Birth hospital type did not significantly impact the odds of individual secondary outcomes after controlling for these variables.

Maternal Cervical Dilation on Admission

The degree of cervical dilatation at presentation to the obstetrics triage was used as a proxy to evaluate preventable VLBW deliveries at non-SPCs. Data on the degree of cervical dilatation was available for 200 mothers who gave birth to 216 VLBW infants at non-SPCs. Seventy-five mothers (37.5%) presented with cervical dilation 4 cm or less; 28 mothers had no cervical dilation. The time between admission and delivery was within 4 hours for 64% (*n* = 48) for mothers presenting with cervical dilation 4 cm or less. Among 200 mothers for whom dilata-

tion data were available, 10 (5%) delivered after 12 hours of admission.

DISCUSSION

Previously published reports, including our own work, consistently document excess morbidity and mortality among VLBW preterm infants born at non-SPCs.^{6–10} The collective findings support the value of regional perinatal systems of care that support timely evaluation and transfer of mothers presenting in preterm labor at a non-SPCs.

Within a year of initiating outreach efforts in late 2002, maternal transfer rates increased from 75% to nearly 90%. As before, remaining outborn preterm infants experienced significantly higher mortality or major morbidity, with intracranial hemorrhage remaining a major concern. Outborn preterm infants are less likely to benefit from antenatal corticosteroid administration because of the short interval between treatment and delivery. However, even in the non-SPC setting, antenatal steroids improve outcome (Table 6). Antenatal steroids reduce the risk of intracranial hemorrhage (ICH) associated with transport.¹¹ Our

TABLE 6 Odds Ratios and 95% Confidence Intervals in Models That Included Birth Hospital Type and Maternal, Infant, and Practice Variables

Factor	Major Morbidity or Death	Death	Bronchopulmonary Dysplasia or Death	Intracranial Hemorrhage or Death	Retinopathy of Prematurity or Death	Necrotizing Enterocolitis or Death
Nonpractice variables model	3.05 (2.12–4.39)	2.11 (1.44–3.10)	1.84 (1.27–2.65)	3.51 (2.42–5.10)	2.24 (1.54–3.26)	2.14 (1.49e3.07)
Add Clinical Risk Index for Babies	2.44 (1.66–3.59)	1.43 (0.94–2.19)	1.38 (0.92–2.06)	2.60 (1.73–3.90)	1.63 (1.08–2.45)	1.61 (1.09–2.38)
Add steroids and antibiotics and Clinical Risk Index for Babies	1.30 (0.80–2.12)	0.83 (0.48–1.43)	1.23 (0.75–2.02)	1.20 (0.71–2.03)	1.12 (0.67–1.87)	0.98 (0.60–1.61)

study compared inborn and outborn neonates. Not all outborn neonates were transferred to an SPC in our study (26% were not transferred). These included neonates who died and were not evaluated for ICH. No modifications within the scope of the Cincinnati Perinatal Outreach Program, neonatal transport, or clinical coverage have occurred since 1996 to account for differences in outcomes between SPCs and non-SPCs. Outreach education should promote antenatal steroid use, especially for those deliveries at non-SPCs likely to result in neonatal transfer to an SPC.

Van Dyke et al¹² recently published an evaluation of adherence to national Centers for Disease Control and Prevention recommendations for antenatal screening for maternal group B streptococcus colonization. They noted rapid clinician adherence to guidelines after publication in 2002 but do not address why this occurred. During the 1990s, France established a perinatal regionalization policy requiring level 1 and 2 maternity units to establish referral relationships with level 3 units to facilitate maternal transfer before 33 weeks' gestation. The strategy reduced the percentage of preterm deliveries of less than 33 weeks' gestation at a level 1 or 2 facility from 86% to 34%.¹³ However, subsequent efforts have not substantially improved transfer rates. Barriers to transfer included antenatal bleeding, disadvantaged socioeconomic status, and increasing distance from level 3 locations. Cervical dilatation at initial presentation was not evaluated.¹⁴

A core component of clinical effectiveness is rapid dissemination of reliable information. Here, we leveraged longstanding service and outreach education relationships in our region to effect an improvement in care. Guide-

lines jointly published by the American Academy of Pediatrics and the American College of Obstetrics and Gynecology have promoted delivery of neonates who are less than 32 weeks' gestation as a quality outcome measure since 1997.^{1,2} Similarly, since 1990, the United States Public Health Service has published and promoted national health promotion and disease prevention objectives. Healthy People 2000 (published in 1990) and Healthy People 2010 (published in 2000) included increasing the proportion of VLBW infants born at level 3 hospitals or SPCs as a key objective.^{15,3} These guidelines and objectives were established during the period of our previously published study and remain in the most current versions of these publications. We postulate that improvements in regional maternal transfers to SPCs are a consequence of our regional outreach activities.

On the basis of our cervical dilatation data, additional improvements in maternal transfer rates are possible. In our region, the majority of non-SPCs are located within 30 minutes of an SPC. These findings suggest that a population of mothers still delivering at a non-SPCs could be safely transferred to an SPC before delivery. Other factors beyond cervical dilatation, including transport distance to the SPC, must be considered. Reliable algorithms will enhance obstetrical decision making for delivery at a non-SPC.

Our retrospective longitudinal study design has intrinsic limitations. Other unidentified obstetrical or hospital practices may have influenced outcomes at non-SPCs or SPCs. However, the geographically defined, population-based nature of our clinical program minimizes potential selection bias associated with a particular practitioner or health care institution. The

study population in our previous report included infants weighing less than 1500 g but may have included some growth-restricted neonates delivered beyond 32 weeks' gestation. The current study population included the highest-risk patients: those weighing less than 1500 g and at less than 32 weeks' gestation. This allows for maternity-unit nurses and obstetricians to use estimated fetal weight or gestational age as criteria for initiating maternal transfer to SPCs.

Recent studies emphasize the value of high-volume level 3 NICU care to minimize neonatal mortality among VLBW infants.^{10,16} Effective maternal transfer strategies enhance this value. Our data demonstrate that transferring 8 mothers saves 1 infant life and transferring 9 mothers prevents 1 episode of severe ICH.

Chien et al⁸ speculated that improvements in regional transfer rates might select for sicker outborn infants whose mothers had less exposure to prenatal care and antenatal steroid administration. Compared with our previous study (Warner et al), we find that the odds ratio for death or major morbidity in outborn patients increased from 2.64 to 3.05.⁴

CONCLUSIONS

The residual outborn population in our region is sicker and at even higher risk than before. These infants and their mothers represent a distinct cohort amenable to prospective analyses. Understanding the contribution of factors such as access to care, transportation, and health literacy should provide crucial insight for development of future intervention-based strategies to further minimize the incidence of outborn preterm delivery.

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