Neonatal Regionalization through Telemedicine Using a Community-based Research and Education Core Facility

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Introduction: Although regionalization of neonatal intensive care is associated with improved outcomes, implementation has been difficult because of increased deliveries of sicker neonates in smaller nurseries. Telemedicine has been used successfully for medical care and education but it has never been utilized to modify patterns of delivery in an established state network.

Methods: The Community Based Research and Education Core Facility of the Center for Translational Neuroscience established a network of 15 telemedicine units with real-time teleconferencing and diagnostic quality imaging, called Telenursery, placed in neonatal intensive care units, using T1 lines to link these units with a large academic neonatal practice. Weekly educational conferences were conducted to establish guidelines for obstetrical, neonatal and pediatric care in a program called PedsPLACE (Physician Learning and Collaborative Education). Patterns of delivery were assessed through a linked Medicaid database before and after the Telenursery initiative to determine if the most at-risk neonates were transferred to the academic perinatal center for delivery. Clinician satisfaction with the PedsPLACE educational conference was high as assessed through written survey instruments.

Results: Medicaid deliveries at the regional perinatal centers increased from 23.8% before the intervention to 33% in neonates between 500 and 999 grams ($P<.05$) and was unchanged in neonates between 2001–2500 grams.

Conclusion: Telemedicine is an effective way to translate evidence-based medicine into clinical care when combined with a general educational conference. Patterns of deliveries appear to be changing so that those newborns at highest risk are being referred to the regional perinatal centers. (*Ethn Dis*. 2010;20[Suppl 1]: S1-136–S1-140)

Key Words: Infant, Premature, Intensive Care Units, Neonatal, Regionalization, Telemedicine

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Introduction

Research on regionalization of neonatal intensive care has demonstrated the benefits of delivering high-risk neonates in larger nurseries with experienced subspecialists to care for them. Regionalization has led to lower death rates when the smallest neonates are delivered at hospitals with neonatal intensive care units (NICUs) equipped to care for the most at-risk babies.[1,2] The benefits of delivery and care at such facilities are especially clear for the sickest and most immature neonates. Many states including Arkansas have attempted to ensure regionalization of perinatal care, but results have been disheartening with minimal shift towards regionalization of care for this vulnerable population, despite overwhelming evidence of its effectiveness.[3,4] Further, delivery of very low birth weight (VLBW, <1500 grams) infants at regional perinatal centers is significantly lower for African American and Hispanic women, uninsured women, and women residing in rural areas and/or areas located more than 25 miles from the nearest NICU.[5,6]

To address these issues, the Center for Translational Neuroscience's Community Based Research and Education Core Facility, funded by the National Center for Research Resources, implemented a weekly educational conference, Pediatric Physician Learning and Collaborative Education (Peds PLACE). This program was coordinated with a weekly obstetrical program, Antenatal Neonatal Guidelines and Educational Learning System (ANGELS) funded by Arkansas Medicaid. These telemedicine initiatives functioned under a cooperative agreement, between the University of Arkansas for Medical Sciences (UAMS), a large academic perinatal program and the community hospitals, designed to promote greater interactive education through telemedicine. Education through telemedicine has proven to be highly successful,[7] and it was hoped that telemedicine education would enhance appropriate transfer of high-risk pregnancies to regional perinatal centers as a result of these initiatives. This study examined the impact of these programs on patterns of delivery for high-risk pregnancies in Arkansas, with a specific focus on women residing in underserved areas of the state. By encouraging community physicians to refer high-risk pregnancies to regional perinatal centers, the program was expected to increase the proportion of Extremely Low Birth Weight (ELBW, <1000 grams) neonates delivered at the state's academic medical center, offering advanced maternal-fetal care. Peds PLACE and Telenursery were not expected to increase the proportion of larger, healthier babies delivered in the academic perinatal center.

Methods

This program used a rural telemedicine network of interactive videoconference equipment to allow neonatal and maternal-fetal medicine subspecialists at the academic medical center to consult with patients and their commu-

nity physicians regarding high-risk conditions. The network is in place at nearly 40 rural hospitals and other local health agencies across the state and includes 15 Telenursery sites (Figure 1). It maintains a 24-hour call center staffed by experienced nurses who provide case management for patients and their physicians across the state including transfer of high-risk patients to regional perinatal centers for delivery if appropriate. Additionally, it develops, maintains, and disseminates a set of clinical guidelines and protocols to support evidence-based management and referral of neonatal and high-risk pregnancy conditions. Arkansas' pediatric and obstetrical providers have opportunities to review and comment on drafts of individual protocols as they are developed through live videoconferences. Program activities were implemented in 2003 for ANGELS and 2004 for the educational PedsPLACE and telenursery programs.

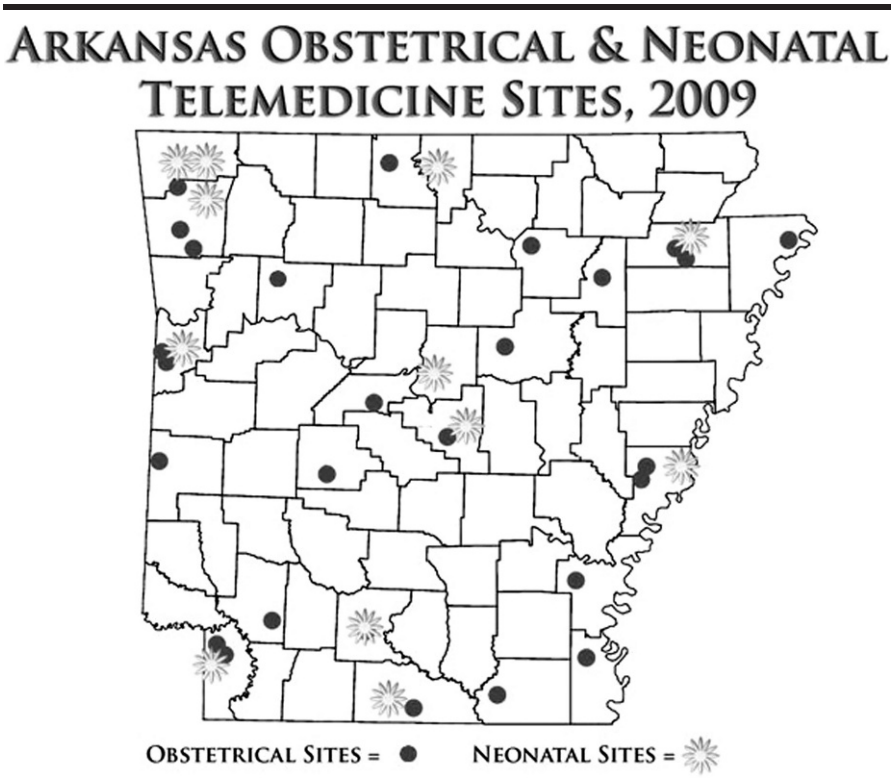

Fig 1. Arkansas map illustrating Telenursery coverage

This analysis compared patterns of delivery for Low Birth Weight (LBW, <2500 grams) deliveries occurring during the two years prior to implementation of telemedicine (2001–2002) with deliveries during the two years following program implementation (April, 2003–2004). The analysis considered three types of hospital facilities that provide obstetrical services in Arkansas: (1) the state's academic medical center, a perinatal center with 24-hour coverage by maternal-fetal medicine subspecialists along with a neonatal intensive care unit (NICU) with 24 hour, in-house faculty neonatology; (2) community hospitals with NICU's with neonatology coverage; and (3) community NICU's without neonatology coverage.

Data from all LBW infants born alive in Arkansas hospitals during calendar years 2001 through 2004 with birth weights ≥500 grams and ≤2499 grams were used. Infants delivered at <500 grams were excluded from the analysis. Birth records from the Arkansas Vital Statistics Data System were used to identify all births during the 4 year period with a birth weight <2500 grams. A total of 12,258 births were included, including infants transferred to hospital facilities outside the state after delivery. Birth records for these infants were linked with corresponding hospitalization records from the Arkansas Hospital Discharge Data System (HDDS) to obtain information on the type of hospital where the delivery occurred and the type of hospital (if any) where the infant was transferred after delivery. The HDDS is an all-payer database containing clinical and administrative information on each admission occurring at an Arkansas hospital. More than 98 percent of the LBW birth records from 2001–2004 were successfully matched with their corresponding HDDS hospitalization records.

The primary outcome measures in this analysis are the proportions of VLBW and ELBW infants delivered in each of the hospital settings defined above. Bivariate and multivariate statistical methods were used to test whether a time trend in the delivery patterns suggested that implementation of the telemedicine program was associated with increases in the likelihood that VLBW and ELBW infants would deliver at the academic medical center or at community hospitals.

STATISTICAL ANALYSIS

Multivariate statistical models were used to risk adjust outcome measures for differences in case mix observed across delivery settings. The model controls for maternal and infant characteristics including birth weight, gestational age, congenital abnormalities, maternal age, month of prenatal care initiation, number of prenatal visits, maternal race and ethnicity, maternal education, type of health insurance, rural or urban area of residence, and distance from residence to the academic

medical center. Estimates from the model are used to construct risk-adjusted measures of the likelihood of academic and community hospital deliveries both before and after program implementation. The primary outcome measures in this analysis are the proportions of VLBW and ELBW infants delivered in each of the hospital settings defined above. Bivariate and multivariate statistical methods were used to test whether a time trend in the delivery patterns suggested that implementation of the telemedicine program was associated with increases in the likelihood that VLBW and ELBW infants would deliver at the academic medical center or at community hospitals. Delivery patterns for higher birth weight infants (1500–2499 grams) were used as comparison groups in this analysis. All statistical analyses were performed using the STATA 9.0 software system.

RESULTS

The total LBW deliveries increased moderately during the four-year study period, from 2965 in 2001 to 3154 in 2004. Across all years, 7% of the LBW infants born during this period had birth weights of 500–999 grams, compared with 8% with weights of 1000–1499 grams, and 19% with weights of 1500–1999 grams. The proportion of infants born weighing 500–999 grams increased modestly over the period, from 4.1% of all LBW births in 2001 to 4.8% in 2004. More than half of the births were to women covered by Medicaid, and 70% were to White women. On average, women delivering LBW infants lived more than 80 miles from the academic perinatal center.

Prior to program implementation, more than half of all LBW deliveries occurred in non-NICU community hospitals; this proportion did not change significantly after telemedicine. Approximately 18% of these deliveries occurred at the academic medical center

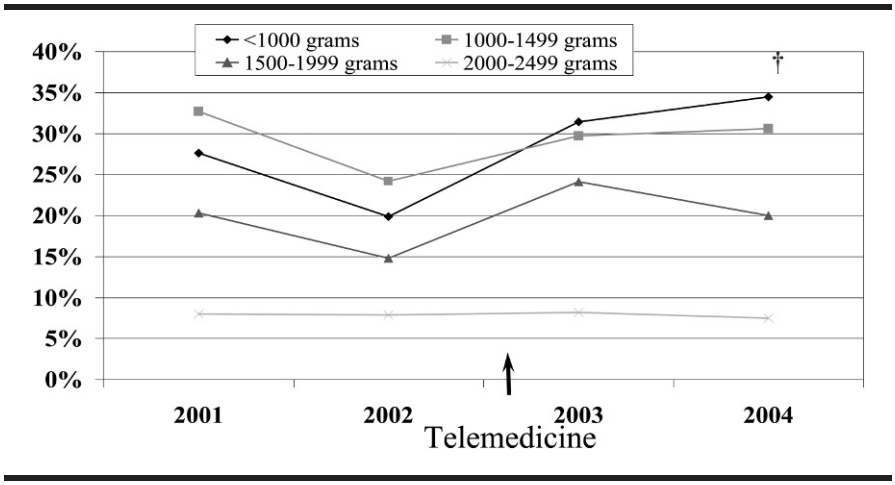

Fig 2. Proportion of neonates in outlying areas delivered at the perinatal center by weight and year of birth (Regression-adjusted estimates controlling for maternal risks, insurance source, socioeconomic characteristics, and race/ethnicity; $P<.05$)

prior to telemedicine implementation, and this proportion increased by less than 1 percentage point after implementation. The proportion of infants who were delivered at NICU community hospitals decreased modestly from 30.1% to 28.8%. Among the highest-risk infants weighing 500–999 grams, the proportion delivered at the academic medical center remained stable after telemedicine implementation (42.0% to 41.6%), while the proportion delivered at community NICU hospitals decreased by nearly 5 percentage points (35.3% to 30.7%).

The patterns of delivery appeared notably different for women residing in outlying areas more than 80 miles from the academic medical center where there was enhanced telemedicine coverage (Figure 2). In these areas, the proportion of infants 500–999 grams who were delivered at the academic medical center increased from 40.7 to 46.8 after telemedicine implementation, while the proportion who were delivered at community NICU hospitals decreased substantially (from 26.8% to 17.5%). The proportion of 500–999 gram infants who were delivered at non-NICU hospitals increased from 32.5% to 35.7%.

Patterns of delivery for VLBW and LBW births varied according to the nature and severity of the high risk pregnancy, and insurance coverage (uninsured women and those covered by Medicaid were significantly more likely than their privately-insured counterparts to deliver at the academic medical center). Regression estimates indicated that patterns of delivery for the highest risk pregnancies changed significantly in 2003, the beginning of the initial telemedicine program. Compared to infants born during the baseline year of 2002, high-risk LBW high-risk infants born in 2003 were 30% more likely to be delivered at the academic medical center after adjusting for differences in case mix and risk factors ($P<.05$). Similarly, high-risk infants born after Telenursery and PedsPLACE telemedicine implementation in 2004 were 14% more likely to be delivered at the academic medical center compared to infants born in 2002, although this difference did not reach statistical significance ($P=.24$). By comparison, infants born in 2003 and 2004 were no more likely to be delivered at Level III community hospitals than their counterparts born prior to 2002 (Table 1).

The largest increase in academic medical center deliveries occurred among the smallest infants (500–999 grams) born to mothers residing more than 80 miles from the center. For

Table 1. Results from multinomial logistic regression model predicting place of delivery for low birth weight infants

Variable	Relative Risk	95% Confidence Interval		*P* value
Probability of delivery at academic medical center				
Birth weight (reference: 2000–2499 grams)				
500–999 grams	5.778	3.719	8.977	.000
1000–1499 grams	10.753	7.030	16.447	.000
1500–1999 grams	3.063	2.291	4.095	.000
Gestational age (months)	0.914	0.898	0.929	.000
Congenital condition	4.006	3.027	5.301	.000
Race (reference: white)				
Black	2.136	1.884	2.422	.000
Asian	1.356	0.738	2.495	.327
American Indian/Native American	1.500	0.816	2.757	.192
Other race	0.955	0.582	1.568	.856
Hispanic ethnicity	1.895	1.497	2.399	.000
Maternal age (years)	1.018	1.008	1.028	.000
Insurance type (reference: private non-HMO)				
Medicaid	2.267	1.939	2.650	.000
Other public program	0.514	0.295	0.895	.019
Uninsured	3.112	2.428	3.988	.000
Private HMO	4.406	3.598	5.395	.000
Distance to academic medical center (mi)	0.985	0.984	0.986	.000
Time period (reference: 2002 pre-ANGELS)				
2001 (pre-ANGELS)	1.267	1.016	1.580	.035
2003 (post-ANGELS)	1.302	1.053	1.611	.015
2004 (post-ANGELS)	1.138	0.916	1.415	.242

these infants, the case mix-adjusted likelihood of delivery at the academic medical center increased from 27.6% in 2001 to 34.5% in 2004 ($P<.01$). Larger infants born to mothers in these distant locations did not show a consistent increase in likelihood of delivery at the academic medical center. Among all LBW infants, the case mix-adjusted probability of academic medical center delivery increased by 7.2% between the pre- and post-telemedicine periods ($P<.05$).

DISCUSSION

ELBW infants born in Arkansas in 2003 and 2004, the time period immediately following the implementation of our telemedicine research and education programs, were more likely to be delivered at a university medical center than babies born in 2002. Shifts in delivery location were concentrated in women residing in rural areas more than 80 miles from the academic medical center. The degree of change was significant but modest, with less than an 8% increase in the likelihood of delivery at the academic medical center. As expected, moderately LBW neonates weighing 1500–2499 grams showed no change in patterns of delivery, suggesting that this program was successful in selectively targeting the highest-risk pregnancies for delivery at the academic medical center. Additionally, there was no change in delivery site for VLBW babies. Given the length of time often required to change physician decision-making and practice patterns, and given the statewide scale of our telemedicine program, the results achieved after the initial two years of implementation are encouraging.

Typically, smaller infants who deliver at larger academic medical centers experience significantly lower adjusted mortality rates compared with infants delivered at non-NICU facilities according to most,[3,8] but not all,[9] studies. Thus, regionalization of care is important because it leads to a decrease in neonatal mortality.

IMPLICATIONS FOR IMPROVING HEALTH DISPARITIES

Electronic education has shown encouraging results for continuing education among physicians and nurses.[7,10] This mode of communication is ideally suited to community practitioners who live in rural areas.[11,12] This study suggests that telemedicine-based education and consultation combined with guideline dissemination can be effective in enhancing access to beneficial specialty care for the management of high risk pregnancies, particularly for rural and underserved populations. In doing so, these approaches may facilitate the

development of regionalized systems of perinatal care that improve access and health outcomes for LBW infants.

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