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Telemedicine Collaboration Improves Perinatal Regionalization and Lowers Statewide Infant Mortality

Elizabeth W. Kim, MD[1], **Terri J. Teague-Ross, MS**[2], **William W. Greenfield, MD**[2], **D. Keith Williams, PhD**[3], **Dennis Kuo, MD**[2], and **Richard W. Hall, MD**[1]

[1]Department of Pediatrics/Neonatology, College of Medicine, University of Arkansas for Medical Sciences and Arkansas Children's Hospital, Little Rock, Arkansas

[2]Department of Obstetrics and Gynecology, Center for Distance Health, College of Medicine, University of Arkansas for Medical Sciences, Little Rock, Arkansas

[3]Department of Biostatistics, University of Arkansas for Medical Sciences, Little Rock, Arkansas

Abstract

OBJECTIVES—We assessed a telemedicine (TM) network's effects on decreasing deliveries of very low birth-weight (VLBW, <1500 grams) neonates in hospitals without Neonatal Intensive Care Units (NICUs) and statewide infant mortality.

STUDY DESIGN—This prospective study used obstetrical and neonatal interventions through TM consults, education, and census rounds with 9 hospitals from July 1, 2009 – March 31, 2010. Using a generalized linear model, Medicaid data compared VLBW birth sites, mortality, and morbidity before and after TM use. Arkansas Health Department data and chi square analysis were used to compare infant mortality.

RESULTS—Deliveries of VLBW neonates in targeted hospitals decreased from 13.1% to 7.0% (p=0.0099); deliveries of VLBW neonates in remaining hospitals was unchanged. Mortality decreased in targeted hospitals (13.0% before TM and 6.7% after TM). Statewide infant mortality decreased from 8.5 to 7.0 per 1000 deliveries (p=0.043).

CONCLUSIONS—TM decreased deliveries of VLBW neonates in hospitals without NICUs and was associated with decreased statewide infant mortality..

Keywords

Very Low Birth Weight; Premature; Neonates; Neonatal; Neonatal Intensive Care Unit

INTRODUCTION

Very low birth weight (VLBW [birth weight <1500 g) neonates are among the most critically ill and fragile patients within the modern healthcare system. Mortality rates range from 15% to 25%[1, 2, 3] and survival with major morbidity remains high.[1] VLBW neonates

Corresponding Author: Elizabeth W. Kim, MD Assistant Professor Department of Pediatrics/Neonatology University of Arkansas for Medical Sciences Arkansas Children's Hospital 4301 West Markham, Slot #512-5B Little Rock, Arkansas 72205 Phone: 501-526-3580 Fax: 501-526-3589 kimelizabethw@uams.edu.

born in large perinatal centers have improved survival and adverse outcomes when compared to similar neonates born in hospitals without subspecialty care;[4, 5, 6, 7] thus, regionalization has the potential to reduce mortality and morbidity in the VLBW neonate population. Unfortunately, despite the well-known benefits of regionalization, de-regionalization of NICU care has continued to occur[7]. Perinatal regionalization connotes a system of healthcare for mothers and neonates organized within a geographic area.[8] This concept assesses risk, promotes resource allocation and appropriate patient transport, and differentiates levels of care to deliver the best quality of care in the most economical manner.[9] Guidelines for Perinatal Care[10], endorsed by the American Academy of Pediatrics and the American College of Obstetrics and Gynecology, have defined levels of care and minimum requirements for caring for high-risk pregnancies likely to result in premature neonates. These guidelines recommend that neonates <32 weeks gestation or <1500 grams be delivered in Level III perinatal centers, which provide neonatal and subspecialty care. However, as the number of hospitals caring for these mothers and their infants has increased, the movement toward regionalized perinatal care has declined. Further, there is substantial variation in effective regionalized perinatal care among states.[3, 7, 11, 12, 13] The Federal Maternal and Child Health Bureau established a goal aimed at delivering 90% of VLBW neonates in Level III perinatal centers.[14] In 2009, according to the US Maternal and Child Health Bureau, only 7 states achieved that goal.[15] Thus, interventions to improve regionalized care and lower mortality are desperately needed. Telemedicine (TM) offers a novel solution for bringing patients with the greatest needs together with tertiary care resources.[12] TM has been used in NICUs to assess for retinopathy of prematurity in VLBW neonates[16, 17] in obstetrical units to provide fetal ultrasonography,[11] in cardiology to perform echocardiography,[18] and to provide education[11] and family support.[19]

In 2003, Arkansas established a statewide system for high-risk obstetrics and neonatology, Antenatal and Neonatal Guidelines, Education and Learning System (ANGELS). ANGELS provided an infrastructure for TM collaboration, consultation, and development and adoption of best practices.[11, 20] However, TM effectiveness in improving regionalization in high-risk neonatal populations has not been fully demonstrated. This study was undertaken to determine if TM could decrease VLBW deliveries in hospitals without NICUs, impact morbidity and mortality in this patient population, and decrease statewide infant mortality.

METHODS

Telemedicine Outreach Utilizing Collaborative Healthcare (TOUCH) Program

In 2009, the Centers for Medicare and Medicaid Services (CMS), a component of the United States Department of Health and Human Services, partnered with the University of Arkansas for Medical Sciences (UAMS) to initiate the TOUCH project. Nine obstetric and nursery sites across the state (Figure 1), chosen because of high-birth volume, were designated as TM hospitals, and included Jefferson Regional Medical Center (Pine Bluff, AR), Mercy Medical Center (Rogers, AR), National Park Medical Center (Hot Springs, AR), Ouachita County Medical Center (Camden, AR), St. Bernard's Regional Medical Center (Jonesboro, AR), St. Edward Mercy Medical Center (Fort Smith, AR), CHRISTUS St. Michael Health System (Texarkana, TX), Washington Regional Medical Center (Fayetteville, AR), and

Willow Creek Women's Hospital (Johnson, AR). Five of the 9 hospitals did not offer specialized newborn care and were the targeted hospitals.

In the initial project phase, Tandberg® (Atlanta, GA) telemedicine codec camera carts and clinical equipment were purchased. The units were placed in the 9 TM hospitals with the cooperative effort of UAMS video support personnel working with nurse managers or other administrative officials at the outlying hospitals. Connectivity was established using T1 lines capable of a data transfer speed of 1.5 megabits per second. UAMS outreach staff, including a neonatologist, an obstetrician, and registered nurses, traveled to the outlying sites to perform initial in-service training on the use of TM technology. The sites were educated on the stepwise process of contacting the well-established obstetric ANGELS Call Center and the neonatal Angel One Transport Team (Arkansas Children's Hospital [ACH] transport team) in order to facilitate consultations and transports of obstetric and neonatal patients. The ANGELS Call Center and Angel One Transport Team are staffed with registered nurses, who field calls from referring physicians. Test calls between providers at TM hospitals and those at UAMS were conducted prior to initiating the program to ensure the TM connection was in place and that the video quality was acceptable. TM support was provided by 1) twice weekly TM census rounds provided by obstetrics faculty at UAMS, 2) continuous (24/7) TM obstetrics consultation through the ANGELS Call Center, 3) three times weekly TM neonatal rounds conducted with neonatology faculty at UAMS, 4) continuous (24/7) TM neonatology consultation, 5) education in the form of peer-reviewed treatment guidelines based on current standards of care (available at www.uams.edu/angels), 6) three times weekly interactive video education conferences for obstetrics and pediatrics, and 7) ongoing TM social support, such as visually introducing caregivers from the perinatal center to parents and visualization of their infants following delivery. TM census rounds consisted of participating hospital staff communicating their census, availability for back transport of UAMS or ACH patients, anticipated problem deliveries, and need for consultation. Rounds began at 8:15 AM on Monday, Wednesday, and Friday and lasted 15–30 minutes. Staff obstetricians, neonatologists, and referring physicians were able to discuss patients of interest, view patients at the time of consultation, and collaborate on case management including evaluation of patients for transfer to a higher level of care. Educational opportunities included two weekly obstetrical teleconferences, Obstetrical Grand Rounds and High Risk Obstetrical Case Presentations, and a weekly interactive pediatric lecture on neonatal and pediatric topics (Peds PLACE).[21] The UAMS Institutional Review Board approved this study prior to program initiation and data collection.

Study Design

This was a prospective study, with pre- and post-assessment. The program was established and the study conducted over a 13 month period from March 1, 2009, through March 31, 2010. The first 4 months (March 1–June 30, 2009) were dedicated to establishing connectivity with the community hospitals and were designated as a training period. The program was in full operation for the remaining 9 months. Following the program completion, Medicaid data for VLBW neonates, as indicated by their International Classification of Diseases, Book 9 (ICD-9) diagnosis codes on hospital and physician claims, were obtained for the 9-month study period and for the 9-month period prior to

initiation of the TM program (July 1, 2008 – March 31, 2009). The methodology for matching birth and death certificates with claims data for Medicaid has been described previously.[22] Mortality and morbidity were assigned to the birth hospitals for these neonates, which were determined from claims data and were categorized as being a TM hospital-NICU, TM hospital-non-NICU, non-TM hospital-NICU, and non-TM hospital non-NICU. Mortality and morbidity for every patient that was transferred was assigned back to the birth hospital regardless of transfer. Patients from UAMS were analyzed as a separate study group since it was the central TM site. Our primary goal was to utilize TM collaboration to decrease the number of VLBW deliveries at TM hospitals without NICUs. We hypothesized that the number of VLBW neonates delivered in hospitals without a NICU would decrease, thereby improving perinatal regionalization and mortality. Additionally, tracking VLBW deliveries would be an objective way to assess appropriate referrals. Secondary outcome measures included evaluation of changes in morbidity (bronchopulmonary dysplasia, necrotizing enterocolitis, and grade 3-4 IVH).

To determine which hospital, if any, the VLBW neonate was transferred to after delivery, the earliest Medicaid claim for a hospital with an admission date on the same day as the discharge date of the delivery hospital was found. After a transfer hospital was found, the TM and NICU status were determined using the same method that was used for the delivery hospitals. Once the VLBW neonates were identified, we determined if their mothers were also in the Medicaid system by querying a Medicaid table that links mothers and neonates based on various demographic characteristics. If a match was found, the mother's identifier was linked to the VLBW neonate's identifier.[22]

Claims for the VLBW neonates during their first 3 months of life were retrieved from the Medicaid database. Fields such as the recipient's county, dates of service, primary and secondary diagnoses, procedure codes, and paid amount were extracted from these claims. Additionally, for those mothers to whom neonates were matched, delivery claims with a date of service within 2 days of the neonate's date of birth were identified along with the fields for the neonate's claims.

Mortality—Death before hospital discharge was used to assess hospital mortality in Table 2. Statewide infant mortality, death before 1 year of age, was assessed because of concern that this program could be shifting mortality from lower to higher level centers or that neonates were not surviving after discharge. This data was obtained from the Arkansas Department of Health for Arkansas deliveries, and chi square analysis was used to compare infant mortality rates 9 months immediately before (Oct 1, 2008 through June 30, 2009) and after (July 1, 2009 through March 31, 2010) telemedicine intervention.

Statistical Plan

Claims data were evaluated using a generalized linear model with site, time, and a site by time interaction term. This model allows for straightforward statistical tests using for the effect of time at each site. We compared delivery site of VLBW neonates, mortality, and morbidity across hospital groups, and pre- and post-TM. Discharge status, including transfer and death, and length of stay were also evaluated. Secondary outcomes were identified

based on ICD-9 codes recorded on patient Medicaid claims. We compared pre- and post-TM sites of delivery for birth place, mortality, and morbidity across hospital groups. Discharge status, including transfer, death, and length of stay were also evaluated.

Cost

Each telemedicine codec camera cart (complete with integrated speakers, installation, training, and three years support) was purchased at a cost of $17,500. The total cost of network connectivity was $250–$800 per nursery, depending on the internet provider used by each facility and depending on the existing internet connectivity and the individual information technology (IT) needs of each nursery.

RESULTS

According to Medicaid claims data, during the 9-month post-TM period 60 VLBW neonates delivered in hospitals designated as TM hospitals (with and without a NICU), 202 VLBW neonates delivered in non-TM hospitals (with and without a NICU), and 122 VLBW neonates delivered at UAMS (Table 1). Deliveries of VLBW neonates in TM hospitals-non NICU decreased from 50 to 27 neonates (13.1% to 7.0%, P=0.0099) during the study period. The percentage of VLBW deliveries in the remaining hospitals did not change significantly. During this short study period there was a decrease in mortality in the non-NICU-TM hospitals, although study numbers were small (Table 2). Infant mortality statewide decreased during the 9 month study period. Morbidity, including bronchopulmonary dysplasia, necrotizing enterocolitis, and grade 3 and 4 IVH, was unchanged in the TM hospitals-non-NICU in the post-TM period, except the incidence of intraventricular hemorrhage was slightly increased (P=0.03; Table 3). Discharge dispensations are also presented in Table 2.

DISCUSSION

This is the first study of which we are aware that assesses the effects of a TM collaborative program on improving regionalization of perinatal care, leading to a decrease in infant mortality. In a short period of time, delivery patterns were positively impacted in non-NICU-TM hospitals while non-NICU-non-TM hospitals demonstrated no change in delivery patterns. These results support the hypothesis that TM collaboration may decrease the number of VLBW neonates delivered in non-NICU hospitals, and lends support to efforts to enhance appropriate regionalization and thereby decrease infant mortality.

Our study suggests that the use of TM collaboration could play a role in decreasing the number of VLBW neonates delivered in hospitals without NICUs and could decrease overall mortality, which is consistent with numerous other outcome studies.[1,4,5,6,23,24,25,26] This study's mortality rates were similar to rates found in other institutions[27]. Though this study was carried out over a short period of time with a small sample size, our results suggest a reduction in overall mortality in non-NICU-TM hospitals (Table 2). While this may be a reflection of fewer VLBW deliveries in these centers, the overall mortality statewide was lessened during the study period. Thus we do not believe mortality was “shifted” to higher levels of care. Additionally, because overall mortality was lessened, we believe other

conditions may have been impacted by this effort. We believe this reduction may reflect improved physician collaboration via TM between outside providers and neonatologists concerning perinatal management of VLBW neonates in non-NICU-TM hospitals. No reduction in mortality was demonstrated in neonates delivered in NICU-TM hospitals or at UAMS, though this may be influenced by overall patient acuity at these centers.

While deliveries of VLBW neonates in non-NICU-TM hospitals decreased, morbidity including bronchopulmonary dysplasia, grades 3-4 IVH, and necrotizing enterocolitis was not reduced in non-NICU-TM hospitals in the post-TM period (Table 3). The occurrence of these morbidities was similar to that seen in non-TM hospitals. This finding may again be influenced by the short study period and the small study numbers, and small changes in these numbers significantly change the statistical analysis. The demographics of VLBW neonates from outlying TM and non-TM hospitals may also be different from those served by the larger Level III perinatal center. These variables may include neonates born to mothers not willing to transfer or to mothers unsuitable for transfer to a higher level of care secondary to advanced cervical dilation, abruption, or any number of obstetrical complications. These factors would place these patients at risk secondary to delivering in a hospital without a NICU. Morbidity, including grades 3 and 4 IVH and chronic lung disease, are also somewhat more common in neonates that require transport after delivery.[27, 28, 29]

Continued barriers to regionalization have not been consistently well described and clinicians in several locales have attempted to regionalize perinatal care with varying degrees of success. In many states, regionalization efforts were beneficial, were often supported by solid data and, at minimum, displayed a degree of progress.[30, 31, 3233] Efforts have not been as successful in other states, likely due to remaining obstacles such as patient preference concerning delivery hospital, lack of enforcement of levels of care, and lack of penalty or compensation for proper referral of high-risk mothers prior to delivery.[7, 34, 35]

Telemedicine offers a way to “transform care” in the community, similar to the way it has been used in other venues and in areas where access to care is limited.[36, 37] To date, this technology has been used sparingly in the NICU. Armfield in rural Australia used telemedicine to provide a NICU consultation and educational program.[38] As in our program, his telehealth network was generally perceived as useful (although not all clinicians perceived it that way). Additionally, using relatively low bandwidth speeds (128–384 kbs/sec), his group was able to provide services similar to ours, allowing visual assessment of key clinical signs such as chest wall movement, skin color and morphology.[39] Although we noted the same positive results, our program was aimed at obstetrical providers. We used short but frequent contact to maintain more constant communication. We believe this may have encouraged appropriate referrals to more specialized centers, thus lowering mortality in this vulnerable population. Telemedicine has also been used successfully with pediatric intensive care patients to provide subspecialty consultation to community health care providers.[40, 41] In this study, we provided similar consultative services to community health care providers, which may have also lowered death rates in these neonates. However, due to small the sample size and relatively short period of study, these outcomes should be interpreted with caution. A longer study with a larger sample size is needed to confirm the decreased mortality and unchanged morbidity outcomes and disprove the negative increased

morbidity outcome findings, which were likely influenced by other confounders and the small sample size.

Strengths and Limitations

The strengths of this study included the prospective nature of the study that included a statewide group of Medicaid patients and the use of a statewide Medicaid database for data collection. Further, mortality data from the Arkansas Department of Health was used to assess infant mortality. Thus, an entire statewide population was assessed to confirm that lives were being saved, and deaths were not being "shifted" from lower to higher levels of care. UAMS institutional support was vital to the program's technical infrastructure. The leadership within the development team framed the goals and objectives of the program and was persistent in charting its progress before, during, and after data collection. The participating staff at the tertiary care center and the TM hospitals put forth time to learn and use new technology in order to participate in the program.

Our study had some limitations, which include: (1) a short study period, although we were surprised to demonstrate success in changing delivery patterns in such a limited time period, (2) the number of women with unavoidable obstetrical complications necessitating emergent delivery could not be assessed, (3) the use of Medicaid data collection, which may not identify all VLBW neonates due to variation in provider coding (although we believe errors in coding were uncommon due to financial incentives to bill correctly) and does not identify non-Medicaid VLBW neonates (4) a small sample size, which weakens the power of the results for mortality and secondary morbidity outcomes.

CONCLUSIONS

TM offers a powerful new tool to further perinatal regionalization, and thereby decrease infant mortality in VLBW neonates. Further study is needed to determine if these gains in regionalization of NICU care and reductions in mortality can be sustained through continued TM collaboration.

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Abbreviations

ANGELS	Antenatal and Neonatal Guidelines, Education and Learning System
CMS	Centers for Medicare and Medicaid Services
ICD-9	International Classification of Diseases, Book 9

NICU	Neonatal Intensive Care Unit
TM	Telemedicine
TOUCH	Telemedicine Outreach Utilizing Collaborative Healthcare
UAMS	University of Arkansas for Medical Sciences
VLBW	Very Low Birth Weight

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Table 1

Delivery Site of VLBW Neonates during the Project[1]

	TM hospital – non NICU	Non-TM hospital – non NICU	TM hospital – with NICU	Non-TM hospital – with NICU	UAMS
	Number (%)	**Number (%)**	**Number (%)**	**Number (%)**	**Number (%)**
Pre	**50 (13.05)**	90 (23.50)	25 (6.53)	102 (26.63)	116 (30.29)
Post	**27 (7.03)** [2]	91 (23.70)	33 (8.60)	111 (28.91)	122 (31.77)

[1] Comparisons were made pre- and post-TM between TM and non-TM sites with and without a NICU

[2] p=0.0099 for change in distribution of deliveries in targeted hospitals pre- and post-TM

Table 2

Discharge status of VLBW Neonates during the Project

Delivery hospital	Patients	Deceased P value	Home with home care	Home	Transferred	Status not recorded
		Number (%)	Number (%)	Number (%)	Number (%)	Number (%)
TM hospital – non NICU	Pre N = 50	6 (12.00)	4 (8.00)	15 (30.00)	21 (42.00)	4 (8.00)
	Post N = 27	2 (7.41) P=0.175	0	9 (33.33)	16 (59.26)	0
TM hospital – with NICU	Pre N = 25	1 (4.00)	4 (16.00)	16 (64.00)	3 (12.00)	1 (4.00)
	Post N = 33	3 (9.09) P=0.341	4 (12.12)	22 (66.67)	4 (12.12)	0
Non-TM hospital – with NICU	Pre N = 90	11 (12.22)	2 (2.22)	15 (16.67)	58 (64.44)	4 (4.44)
	Post N = 91	6 (6.59) P=0.232	2 (2.20)	14 (15.38)	65 (71.43)	4 (4.40)
Non-TM hospital – with NICU	Pre N=102	13 (12.75)	17 (16.67)	57 (55.88)	15 (14.71)	0
	Post N=111	7 (6.31)[3] P=0.187	27 (24.32)	57 (51.35)	17 (15.32)	3 (2.70)
UAMS	Pre N=116	8 (6.90)	8 (6.90)	41 (35.34)	59 (50.86)	0
	Post N=122	12 (9.84) P=0.374	12 (9.84)	43 (35.25)	55 (45.08)	0
Statewide Infant Mortality	**Pre N= 28,169**	**242 (.85)**				0
	Post N= 28,788	**204 (.71) P=0.043**				

Statewide infant mortality represents death before 1 year of age; discharge status represents survival until hospital discharge

Table 3

Incidence of Morbidity in VLBW Neonates in Pre- and Post-TOUCH Periods[1]

Delivery hospital	Patients	Bronchopulmonary Dysplasia Number (%)	Intraventricular Hemorrhage Number (%)	Necrotizing Enterocolitis Number (%)
TM hospital – non NICU	Pre N=50	5 (10.00)	2 (4.00)	3 (6.00)
	Post N = 27	7 (25.93)[2]	5 (18.52)[3]	3 (11.11)
TM hospital – with NICU	Pre N = 25	2 (8.00)	2 (8.00)	1 (4.00)
	Post N = 33	5 (15.15)	6 (18.18)	2 (6.06)
Non-TM hospital – non NICU	Pre N = 90	23 (25.56)	16 (17.78)	3 (3.33)
	Post N = 91	19 (20.88)	19 (20.88)	7 (7.69)
Non-TM hospital – with NICU	Pre N= 102	24 (23.53)	29 (28.43)	4 (3.92)
	Post N= 111	28 (25.23)	23 (20.72)	8 (7.21)
UAMS	Pre N= 116	48 (41.38)	26 (22.41)	4 (3.45)
	Post N= 122	56 (45.90)	33 (27.05)	11 (9.02)[4]

[1] Morbidities of VLBW neonates examined during the project included bronchopulmonary dysplasia, intraventricular hemorrhage (grades III and IV), and necrotizing enterocolitis. Comparisons were made pre- and post-TM between TM and non-TM sites with and without a NICU.

[2] p=0.066 chi square pre- and post-TM comparison within hospital group

[3] p=0.034 chi square pre- and post-TM comparison within hospital group

[4] p=0.077 chi square pre- and post-TM comparison within hospital group