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Please note: An erratum will be published for this article to add the following reference to pages 237-238 in discussion of the “mobile application targeting pre-teens and teens with asthma.”

Burbank AJ, Hall-Barrow J, Denman RR, Lewis SD, Hewes M, Schellhase DE, Rettiganti M, Luo C, Bylander LA, Brown RH, Perry TT. There’s an app for that: a pilot and feasibility study of mobile-based asthma action plans. Presented at: The American Academy of Allergy Asthma and Immunology Annual Meeting; 2013 February 22-26; San Antonio, TX.

Respectfully,

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Distributing Medical Expertise: The Evolution And Impact Of Telemedicine In Arkansas

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ABSTRACT Arkansas's telemedicine system has evolved since 2003 from a support mechanism for high-risk pregnancy consultations to an initiative that spans medical specialties, including asthma care, pediatric cardiology, gynecology, and mental health. The system has also expanded care to diverse populations, including incarcerated women and people with HIV/AIDS. This article describes the system's evolution, organization, and diverse activities. It also shows how telemedicine can have a positive impact on a rural state and how such a state can become an engine for change regionally. The Arkansas telemedicine system faced classic challenges to uptake and function, in building and sustaining funding, in obtaining insurance reimbursement for services, and in educating patients and providers. The system's impacts on health outcomes and medical practice culture have also reached beyond patient care and provider support. The existing yet continually evolving telemedicine infrastructure and partnerships in Arkansas will respond to the state's inevitable health care reform adaptations from the Affordable Care Act and could provide direction for other states seeking to adopt or expand their telemedicine efforts.

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Practice patterns in Arkansas reflect a problem endemic to US health care: There is an uneven distribution of physician expertise, and experts are clustered in urban locations. Many rural areas of the state lack specialty care services such as maternal fetal medicine, neurology, cardiology, and rehabilitation. This article describes the efforts of one rural state—Arkansas—to overcome this common problem and related shortcomings by developing a statewide telemedicine network, called Arkansas e-Link, that provides clinical care and education to patients and providers.

The University of Arkansas for Medical Sciences, the state's only academic medical center, began offering telemedicine services through a network of broadband connections between community hospitals and the university in

2003. The network was designed to improve the treatment of high-risk pregnancies, specifically by addressing the shortage of specialty obstetrical care in rural Arkansas—where 44 percent of the state's population resides but few obstetricians practice.¹

In 2013 the network included multiple partners and agencies, reaching 454 sites,² and offered access to a range of services, including those in neurology, pediatrics, oncology, and other specialties that are rarely found in rural areas. Medical provider “champions” across the state have supported the network, worked to improve its infrastructure, and identified and addressed needs through telemedical partnerships and intervention. The champions led the expansion of the network into new medical disciplines and specialties, as described in this article. The network is designed to be sustainable

and both responsive to and governed by its users.

The network's primary function is to deliver interactive video medical consultations that virtually unite patients, their local providers, and distant specialists. Continuing medical education and support services also use the network and complement its offerings. The network has altered relationships across providers and institutions statewide, facilitating system-level improvements.

In this article we describe the efforts of Arkansas's only academic medical center to address issues related to the state's rural nature and to equalize access to specialty care throughout the state via the implementation of telemedicine.

The Genesis Of Arkansas Telemedicine

Arkansas uses telemedicine to address the state's complex health and income problems. Arkansas ranks forty-ninth in the nation in terms of women's health³ and forty-eighth in terms of poverty.⁴

Additionally, the state's rate of low-birthweight infants, a mark of poor health outcomes, has been consistently higher than the national average for at least the past twenty-three years.⁵⁻⁸ And all but two of Arkansas's seventy-five counties have been designated as partial or full Medically Underserved Areas—locations that have some or all of the following characteristics: too few providers, high infant mortality, high poverty, and many elderly people.⁹ Most of Arkansas is facing a health care provider shortage.

In 2001 the Arkansas General Assembly increased eligibility for prenatal care in the state's Medicaid program.¹⁰ Two years later the program covered approximately 55 percent of deliveries in the state¹¹ and spent more than \$13 million to care for only a small proportion of Arkansas's medically fragile children.¹² Faced with decreasing budgets, state Medicaid officials sought new approaches to providing care for high-risk obstetric patients.

One of the authors, Curtis Lowery—a maternal and fetal medicine specialist at the state's academic medical center—realized that video-based obstetrical consultations with the capacity to review real-time ultrasounds was a possible solution, if the right resources and support were available. Lowery approached representatives of the state Medicaid program and state medical society and proposed a statewide obstetrical telemedicine system that would connect urban specialists with rural patients and providers. The state Medicaid program funded a new obstetrical telemedicine program—the Antenatal and Neonatal Guidelines, Education, and Learning System (ANGELS)—and adopted a statewide policy

for telemedicine reimbursement that gave Arkansas the conditions it needed to improve its dire obstetrical outcomes.¹³

Since the 1990s many states—including Arkansas, Iowa, Kansas, Minnesota, and Texas—have offered health care professionals and consumers continuing education through interactive video programs.¹⁴⁻¹⁸ Using the state's existing educational interactive video network, in 2003 ANGELS equipped rural community hospitals with telemedicine equipment and broadband at no cost. This made it possible for patients in community hospitals to receive real-time interactive video consultations, genetic counseling, and ultrasounds with the ability to detect fetal anomalies—all from specialists at the state's academic medical center.

The first community hospitals in the network shared two characteristics: secure broadband connectivity through the state's educational video network and a local champion who supported the new co-management of patients by obstetrical specialists. The security of the network was ensured by block cipher encryption (a method of encrypting blocks of text), the standard practice of the state and federal governments.

In addition to supplying equipment when the network began, ANGELS creates and reviews obstetrical and neonatal practice guidelines and works with Arkansas's physicians to adapt national evidence-based medicine protocols to meet the needs of rural practices. Guidelines are distributed through the ANGELS website. As of 2013, 101 obstetric, 55 neonatal, and 35 pediatric guidelines have been created and distributed through ANGELS.

ANGELS implemented another component of the network: a call center staffed by nurses twenty-four hours a day, seven days a week. The center's nurses offer immediate guidance to obstetrical providers and patients and facilitate high-risk maternal transports to tertiary care centers for delivery.¹³ Through these actions, ANGELS has helped increase the proportion of low-birthweight infants who are delivered at hospitals with neonatologists, where outcomes are potentially better because of the availability of specialized facilities, equipment, and expertise.

The proportion of low-birthweight infants delivered at the academic medical center was 37.7 percent in 2003; it increased to 42.1 percent in 2004.¹⁹ In addition, the state's sixty-day infant mortality rate declined 0.5 percent between 2003 and 2004.²⁰ Since 2003 ANGELS has provided more than 21,000 high-risk obstetrical telemedicine consultations and facilitated nearly 5,000 maternal transports.

Clinical Expansion

The success of the network in high-risk obstetrics led to the implementation of a new telemedicine program in 2006: the Center for Distance Health (CDH). This program used the ANGELS telemedicine model to meet the needs of providers in other medical disciplines and academic specialty groups.

The CDH established two additional obstetrics-gynecology (OB-GYN) telemedicine consult services in 2006–07. The first was a colposcopy initiative established with funding from the Health Resources and Services Administration (HRSA).²¹ This initiative made it possible to transmit detailed views of a woman's cervix through interactive video. A specialist at the state's academic medical center could view the video in real time and provide guidance to health department nurses in rural settings, who—during the same video session—then conducted cervical cancer biopsies for patients with abnormal Pap smears. Since its inception, this program

has assisted nurses with nearly 1,600 colposcopy procedures, identifying 303 women whose cervical dysplasia (abnormal cell growth) required that tissue be excised.

Another new telemedicine service began in 2007. It was funded by the Arkansas Department of Corrections and provided OB-GYN consultations via interactive video for incarcerated women. In 2012, 309 female prisoners received telemedical care in prison instead of outside it, lessening the security risk and saving the state \$26,000.

The network branched into other medical specialties by expanding the ANGELS telemedicine model and infrastructure (Exhibit 1). In one rural county, specialists provided 3,135 interactive video consults to children at school between 2005 and 2009, offering pediatric and behavioral health care. Cardiac subspecialty consults began in 2006.

In 2012 a mobile application targeting pre-teens and teens with asthma became available.

EXHIBIT 1

The Evolution Of Telemedicine At Arkansas's Academic Medical Center, 2003–13

Year	Population served or focus area				
	Women's health	Pediatrics	Disease-specific care	Emergency care	Regional outreach
2013	Obstetrical surgery	Home-based care for premature babies and genetics	Spinal cord injury	Trauma hand surgery	Obstetrical consults ^a
2012 ^b	HIV/AIDS	Pediatric asthma	Mental health telemedicine certification	— ^c	HIV resource center ^d
2011 ^b	— ^c	— ^c	Geriatrics	— ^c	— ^c
2010 ^e	— ^c	— ^c	— ^c	Trauma Image Repository	Telehealth training, ^f women's health education ^g
2009 ^b	— ^c	— ^c	— ^c	— ^c	— ^c
2008	Women's mental health	Telenursery	Oncology and mental health	Neonatal, neurology, stroke	— ^c
2007	Prison-based OB-GYN	— ^c	— ^c	— ^c	— ^c
2006	Colposcopy	Neonatal intensive care unit	Cardiology	— ^c	— ^c
2005	Perinatal bereavement	School-based pediatrics	— ^c	— ^c	— ^c
2004	— ^c	— ^c	— ^c	— ^c	— ^c
2003	High-risk obstetrics	— ^c	— ^c	— ^c	— ^c

SOURCE Authors' analysis. **NOTE** OB-GYN is obstetrics and gynecology. ^aOklahoma. ^bDuring these years the Arkansas telemedicine network underwent vast expansion after years of planning. ^cPlanning and development. ^dDuring these years, organizations throughout the state planned and prepared to facilitate a vast expansion to the Arkansas network. ^eArkansas, Louisiana, Mississippi. ^fArkansas, Mississippi, Tennessee. ^gThe Mississippi Delta.

The app offered asthma management assistance through text message tips and reminders for controller medication adherence and daily tracking of peak flow and asthma symptoms. Asthma Control Test (ACT) scores were examined pre- and post-intervention for twenty adolescent participants. For participants with uncontrolled asthma at baseline, mean ACT scores improved significantly, from 15.3 (2.5) to 19.1 (4.2) ($p = 0.03$). ACT scores range from 5 to 25, with 19 being considered the score at which asthma is under control.

This mobile health intervention demonstrates the feasibility of integrating remote monitoring technologies into the daily routine of adolescents with asthma. It also suggests that this innovative tool can improve asthma self-management skills as well as asthma symptoms among patients with uncontrolled asthma.

Another telemedicine expansion that built on earlier successes, Arkansas SAVES (Stroke Assistance through Virtual Emergency Support), began in 2008. This program was funded by the state Medicaid program and was designed to connect potential stroke victims in rural emergency departments (EDs) with neurologists at urban hospitals in Arkansas. Using telemedicine, neurologists interpret computed tomography scans performed in rural EDs, consult with patients through video connections, and advise local medical personnel on treatment. Between 2008 and 2013 Arkansas SAVES provided more than 1,800 consults and treated 437 cases of ischemic stroke.

The system created for Arkansas SAVES to securely transmit patients' images from EDs made it possible to expand the use of remote diagnostic services for other trauma patients through the creation of a statewide Trauma Image Repository (TIR). The TIR was established through a partnership among the Arkansas Department of Health, the Arkansas Trauma Communications Center, and the CDH. The TIR serves an essential role in the transfer of patient images from referring hospitals to receiving hospitals. It also permits specialists to determine how care should be delivered for patients with complex conditions and to decide whether a patient should be transferred to another facility for care.

Using a virtual private network connection, providers can send images to the TIR and collect images from it. Providers view images via a secure connection using 128-bit encryption. Between 2010 and 2013, the TIR transmitted 1.7 million images for more than 10,000 patients to sixty-six Arkansas hospitals and six regional trauma centers.

In 2008, as another offshoot of the state's telemedicine infrastructure, pediatric cardiolo-

The success of the network in high-risk obstetrics led to the implementation of the Center for Distance Health.

gists began providing fetal echocardiogram telemedicine consultations by viewing fetal echo images in real time, resulting in approximately a hundred consults annually. The ED at the state's children's hospital was also linked to rural EDs to guide them in caring for fragile infants and complex pediatric cases.

A related initiative, funded through a Centers for Medicare and Medicaid Services Transformation Grant,²² installed interactive video equipment at eight hospital nurseries and labor and delivery units to facilitate the local management of high-risk infants. This telemedicine initiative contributed to a decrease in the rate of deliveries of babies with very low birthweight in hospitals without neonatal intensive care units from 13.1 percent in 2009 to 7.0 percent in 2010 and contributed toward the statewide decrease in infant mortality.²³

Another clinical telemedicine program, the HIV/AIDS Telehealth Resource Center, serves Arkansas's population with telemedicine-based HIV/AIDS education and screening through funding from HRSA.²⁴ In 2012 the center provided 225 health professionals with telehealth training in HIV/AIDS topics in thirty learning sessions.

Another telemedicine program, a tele-rehabilitation initiative funded by the Arkansas Spinal Cord Commission, connects patients in rural communities who have spinal cord injuries with specialty support from an around-the-clock call center. The spinal cord injury initiative assisted twenty patients in 2013, its first year of operation.

The Rehabilitative Services for Persons with Mental Illness initiative, which began in 2012, provides clinical telemedicine evaluation and standards certification for 115 mental health, pediatric mental health, and social work counseling sites that serve patients living in rural communities. Telemedicine training and certification afforded through this initiative help en-

The implementation and expansion of telehealth clinical services have fostered a culture of collaboration.

sure patient privacy, secure network connectivity, and eligibility for Medicaid reimbursement for telemedical consultations. This initiative averages 2,912 patient encounters monthly.

In 2010, seven years after telemedicine efforts were launched in Arkansas, regional initiatives emerged (Exhibit 1). The first such initiative served residents of the Mississippi Delta, an eight-state area that includes Arkansas, providing education to regional providers of maternal and child health care via telemedicine tools.

An expansion of the statewide telemedicine network was recently completed, and new regional partnerships are continually being formed. Thus, it is anticipated that new state and regional programming will become available in 2014 and beyond.

Educational Expansion

The implementation and expansion of all of the telehealth clinical services offered by the state's academic medical center have fostered a culture of cooperation and collaboration. The center's telemedical programs are accompanied by related provider-based education efforts that foster camaraderie between specialists and rural providers.

In 2012 the CDH educated 4,673 participants through distance learning. Moreover, the CDH uses the network to invite distant providers to participate in grand rounds in the fields of OB-GYN, pediatrics, psychosocial issues, psychiatry, and geriatrics and in reviews of case studies, discussions of practice issues, and evidence-based reviews of care.

Pediatrics faculty members at the University of Arkansas for Medical Sciences participate in a learning collaborative that reviews case studies and conducts virtual nursery censuses at community hospitals across Arkansas to facilitate transports of stable hospitalized infants back to their communities.²¹ The collaborative has

provided more than 280 reviews of pediatric case and nursery censuses between its inception in 2007 and 2012.

The CDH's South Central Telehealth Resource Center and its HIV/AIDS Telehealth Resource Center use the network to present education and training to providers across Arkansas and the Mississippi Delta. The centers provided distance education to more than 4,600 participants in 2012.

Infrastructure Expansion

In 2007 the CDH received funding from the Federal Communications Commission's (FCC's) Rural Health Care Pilot Program²⁵ to establish broadband connectivity at 141 sites in Arkansas, including most of the state's hospitals, federally qualified health centers, and local health departments. At this time, oversight of the expanded state network was given to a steering committee that included representatives from different provider sectors who became instrumental in the infrastructure's ongoing management and expansion.

Although approved for funding in 2007, the FCC funds were not available until 2012, when all technical and political requirements associated with the program were addressed. However, in 2010, with the support of the oversight committee, the state's academic medical center received a Broadband Technology Opportunities Program grant from the Department of Commerce.²⁶ This grant upgraded broadband service, supplied telemedicine equipment, or both to 454 sites in Arkansas.²⁷ It also made the state's university-based fiberoptic network the backbone of the statewide telemedicine network, Arkansas e-Link.

After combining this multimillion-dollar initiative with FCC support, Arkansas now has a statewide network, Arkansas e-Link, that includes all of the state's public four-year universities, public two-year colleges, county health departments, and nonprofit hospitals, as well as selected mental health clinics, home health agencies, community health centers, and similar settings.²⁷ Within the telemedical community, Arkansas is generally considered to have one of the best-connected telemedicine networks in the nation.²⁸

Challenges To The Uptake Of Telehealth Services

A number of studies have cited a variety of barriers that have limited the uptake or diffusion of telemedicine in patient care. These barriers include technology limitations and inadequate us-

er training,²⁹ as well as concerns about the credibility of experts consulted about technology and the accuracy of the services provided.³⁰

Other barriers are institutional pressures such as financial disincentives and workflow readjustments, in both the provision and the use of telemedicine.³¹ The absence of advantages to telemedicine compared to the established mode of delivery and the influence of opinion leaders and existing social networks have also been cited as barriers to the uptake of telemedicine.³²

The CDH has been successful in keeping technological barriers at a minimum. The center's full-time technical support staff provides training, manages scheduling, troubleshoots problems, and continually monitors and upgrades technology. The staff also oversees an average of 200 hours of concurrent, scheduled interactive videoconferences every day. In addition, in 2010 and 2013 the CDH became one of fourteen regional telehealth resource centers funded by HRSA to cover the nation, expanding the CDH's specific mission—to provide telemedicine training and support to providers—to Arkansas, Mississippi, and Tennessee.³³

Maintaining financial support for Arkansas e-Link is a continual challenge. As is the case with telemedicine networks in other states,³⁴ the Arkansas network's infrastructure has been financed through grants and state support. The growth of the network was helped considerably by grants that paid the costs of connecting many rural health care providers with the state's academic medical center.

However, grant funds are a finite resource, limited in terms of both their amounts and their time periods. Thus, grants may serve as financial vehicles for launching telemedicine networks, but new vehicles are needed for network sustainability.

To establish sustainability, telemedicine system managers may need to explore other financing models, such as subscription-based financing. However, to help defray the costs of subscription fees that may pose challenges to rural health care providers with limited resources, telemedicine network managers should continually seek available grants and reimbursement opportunities, such as those available through the FCC, to help lower costs to end users.

Telemedical patient consultations can also generate income through third-party reimbursement. The Arkansas Medicaid program reimburses for telemedicine consultations, but most private insurers in the state do not. There are variations across the United States in how and whether telemedicine is covered through insurance.³⁵

For specialists providing these services, tele-

To establish sustainability, telemedicine system managers may need to explore other financing models.

medicine-based activities do not generate substantial revenue. However, through telemedicine outreach to rural patients, specialists may identify potential patients who need ongoing care and reduce unnecessary referrals to tertiary-level care, thus increasing the efficiency of specialty services.³⁶

One of the biggest challenges to the uptake of telemedicine³⁷ is establishing the value of telemedicine compared to traditional care delivery and altering the established workflow and practice patterns of community-based physicians. Arkansas's most frequently used telemedicine services have been highly technical, delivered in settings without specialty medical personnel, or both.

Specialists and a telemedicine outreach director improved uptake by establishing face-to-face relationships with rural community providers by visiting their clinics and generating trust between specialists and providers through direct contacts, including conversations, and specialists' immediate response to rural providers' concerns. Once rural providers are willing to experiment with telemedicine, for either continuing education or patient consultation, the values of the service become apparent and justify the need to alter practice patterns.

The original goal of Arkansas's telemedicine network had been to improve the state's dire obstetrical outcomes. However, the network's impact on aspects of care delivery has been varied. For example, the influence of the network on patterns of maternal transport for delivery of premature infants to hospitals with neonatal intensive care units (NICUs) has been relatively modest.³⁸

Within the state Medicaid program, which covers more than half of the deliveries in Arkansas,³⁹ preterm births were more likely to occur at the state's academic medical center, a tertiary care center, when the mother resided in an area where physicians participated in ANGELS tele-

The network helped erode patterns of isolation and territorialism as health care professionals became more familiar with each other.

conferences and used its call center services. However, there were more powerful predictive factors of NICU use—which indicate a better likelihood of a favorable outcome—such as the presence of local medical expertise and maternal characteristics, including being older than age thirty-four and having education beyond high school.³⁸

Additionally, simply having access to an ANGELS telemedicine site did not increase the chances that a woman would receive care from a specialist. Patients with more than a high school education are more likely to participate in telemedicine consultations than patients with less education. Moreover, patients whose providers participate in ANGELS educational teleconferences are also more likely to participate in telemedicine consultation. African American patients are less likely to participate in telemedicine consultations, compared to other patients. Additionally, older obstetrical patients (those ages 25–34) are more likely than their younger peers to participate in telemedicine consultation. In effect, participation in telemedicine is not simply influenced by geographic access; rather, the referral process is conditioned by other factors, including demographic and socioeconomic factors.³⁸

These observations support what the literature suggests: Physicians' and patients' adaptation to telemedicine is a complex process, and use of the system does not diffuse evenly across practitioners and their patients.⁴⁰

System-Level Impact

Initially, the Arkansas telemedicine network brought together clinical entities—institutions, individuals, and organizational systems, such as

the state's Department of Health—that previously had minimal contact or competed for patients and resources. The incremental increase in the number of sites using the network can be attributed to the successes experienced by early adopters. These providers showed their peers that telemedicine allowed community physicians to better manage patients with complex conditions near their hometowns, without transferring them to tertiary care centers, and to obtain better outcomes with the help of distant specialists.

The network helped erode previous patterns of isolation and territorialism as the health care professionals working at the state's academic medical center, hospitals, clinics, health departments, and other health care entities became more familiar with each other. These providers established interpersonal relationships and identified areas in which cooperation could yield common benefits, particularly by expanding access to limited resources.

Division and competition among Arkansas's hospitals, clinics, and providers were further reduced in 2007 with the collaboration forged by the FCC's Rural Health Care Pilot Program.⁴¹

After the state's academic medical center received the Broadband Technology Opportunities Program grant mentioned above, Arkansas e-Link included 454 sites. As a single high-speed, secure network serving the entire state and connecting health care sites, public four-year universities, and two-year colleges, public safety networks, and academic research institutions. Arkansas e-Link created a new, easy-to-access interface across these organizations.

Telemedicine is also affecting efforts to establish and enforce the designation of hospitals in Arkansas as providers of different levels of perinatal care. As Lillian Blackmon and colleagues reported in 2009, Arkansas is one of only three states with no formal system to designate hospitals by their level of neonatal care, despite the fact that guidelines for such classification have existed since the mid-1970s.⁴² Such designations are a critical foundation for establishing policies for the delivery of high-risk infants in settings that support their survival.⁴³

In 2010 ANGELS distributed practice guidelines that neonates with less than thirty-two weeks' gestation or weighing less than 1,500 grams be delivered at hospitals with "level 3" neonatal intensive care capacity. The guidelines cited ANGELS data that at least one-third of the state's preterm infants were delivered in hospitals without neonatology services.

Pressure from the state's neonatologists and providers of maternal and fetal medicine, the Arkansas chapter of the March of Dimes, the state's children's hospital, the state Medicaid

program, and the Arkansas Department of Health resulted in a series of discussions across hospitals on setting the parameters for a state-wide classification system. These discussions have been more productive than others in the past because of new working relationships among institutions in the telemedicine network and improved communication among physicians across the state.

Furthermore, the existence of the state's telemedicine infrastructure means that decisions about transporting mothers who are in labor can be made more easily and appropriately. That fact has eased concerns that level 3 hospitals would divert all cases of obstetric care to other institutions, but it has also raised expectations that high-risk cases would receive appropriate

consultations from specialists.⁴⁴ The group of agencies and partners described above are nearing consensus about the state's hospital-level perinatal care classification system.

Conclusion

The future holds great promises and challenges as the implementation of the Affordable Care Act and concomitant changes in states' Medicaid systems continue. In a rural state such as Arkansas, a robust telemedicine network can allow providers to see more patients across any distance, which will help serve the influx of new insurance enrollees soon to emerge. Such networks also foster a sense of equality and camaraderie among providers. ■

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