

Telemedicine Penetration and Consultation among Rural Trauma Patients in Critical Access Hospital Emergency Departments in North Dakota

Nicholas M. Mohr, MD, MS¹; Karisa K. Harland, PhD, MPH¹; Elizabeth Chrischilles, PhD²; Julie Donner, MSSW³; Amanda Bell, MHA³; Dan M. Shane, PhD²; Marcia M. Ward, PhD²

¹Carver College of Medicine, ²College of Public Health, University of Iowa, Iowa City, IA; ³Avera eCARE, Sioux Falls, SD

Introduction and Background

Trauma is the leading cause of death for Americans aged 1 to 44 years and is associated with significant morbidity and mortality.¹ Rural trauma patients in particular have disproportionately high injury mortality rates,² but only about half of Americans living in rural states live within 30 minutes of an emergency department (ED).³ To help address the needs of rural trauma patients, ED-based telemedicine services are increasingly being used. For rural residents, use of ED telemedicine offers one strategy to improve access to experienced specialists, timely care, and appropriate treatment.⁴

Avera eCARE provides telemedicine service to rural EDs in the upper Midwest. Avera has built a 130-hospital network in 10 states using a hub and spoke model that connects a board-certified emergency physician and an experienced ED nurse with local ED providers using a real-time audio-video link. The subscription-based service is available for consultation on any patient, and trauma care is one focus of the network. Although only 3.5 percent of all ED encounters in participating hospitals request telemedicine consultation, an estimated 30 percent of total telemedicine consultations provide care for trauma patients.⁵ Avera has become the predominant provider of tele-emergency care in North Dakota.

The objective of this study was to describe the penetration of ED-based telemedicine in North Dakota critical access hospitals (CAHs), and to describe hospital and geographical factors that contribute to increased telemedicine utilization in ED trauma. The mission of the Rural Telehealth Research Center is to advance publicly available, high quality, impartial, clinically informed, and policy-relevant research, so future work in this area will focus on the clinical impact of tele-ED on North Dakota trauma care.

Methods and Purpose

This cohort study analyzed penetration and use of telemedicine among adult trauma patients (age ≥ 18 years) presenting to EDs at North Dakota CAHs from 2008 to 2014. The North Dakota Trauma Registry contains information on traumatic injuries treated in North Dakota hospitals (defined as patients who are admitted to the hospital for more than 48 hours, admitted to an intensive care unit, transferred by ambulance, or who died). The registry was matched with the Avera eEmergency subscription records and call log to identify which patients were treated in a telemedicine-capable hospital and which patients had a telemedicine consultation. While many telemedicine providers care for trauma patients, this study focused on North Dakota data in the Avera network because of the rich data sources available. The trauma registry includes information about injuries, severity of illness, timeliness of care,

Key Findings

- From 2008 to 2014, more than 35 percent ($n = 3,309$) of trauma patients treated in a North Dakota critical access hospital presented to a facility with telemedicine capabilities.
- Among patients presenting to a telemedicine-enabled emergency department, 361 (10.9 percent) were treated with telemedicine consultation.
- After telemedicine was implemented in a critical access hospital, utilization remained constant over time.
- Hospital-level and geographic factors do not explain differences in telemedicine penetration or use for trauma patients.

procedures, interhospital transfer, and inpatient care. Avera eEmergency was the predominant ED-based telemedicine provider operating in North Dakota during the study period. Starting in 2012, the trauma registry also contained data on which patients had an ED-based telemedicine consultation, so this variable was used to screen for CAHs with active telemedicine programs other than Avera eEmergency (one hospital). For the purposes of this analysis, only those trauma cases seen in a CAH ED were included, and cases seen in the non-Avera telemedicine-enabled hospital were excluded.

In a telemedicine-enabled ED, a rural clinician evaluates a patient, and if (s)he feels that additional expertise is necessary, (s)he activates a button on the wall, establishing a two-way, high-definition, audio-video connection with an emergency physician-nurse team in Avera’s hub in Sioux Falls, South Dakota. The team in the hub can provide recommendations for clinical care, help with documentation, or help to arrange inter-hospital transfer, as necessary.

Telemedicine-enabled hospitals were defined as those for which a hospital had an active subscription with Avera eEmergency. Telemedicine utilization was defined as a case in which a clinician in a rural hospital activated the network for consultation by a provider at Avera’s telemedicine hub. Hospital-level factors were obtained from the 2012 American Hospital Association survey. All statistical comparisons were considered significant if $p < 0.05$, using two-tailed tests.

Findings

Of the 32,826 adult trauma patients in North Dakota from 2008 to 2014, nearly one-third (28.4 percent) presented initially to a CAH, and 35.6 percent of those presented to a CAH with telemedicine capabilities. During the study period, Avera eEmergency telemedicine availability increased from none to 29 hospitals (of 36 CAHs). Telemedicine was used to support care for 10.9 percent ($n = 361$) of adult trauma patients in telemedicine-capable CAHs (most telemedicine-capable hospitals had telemedicine available for only a portion of the period).

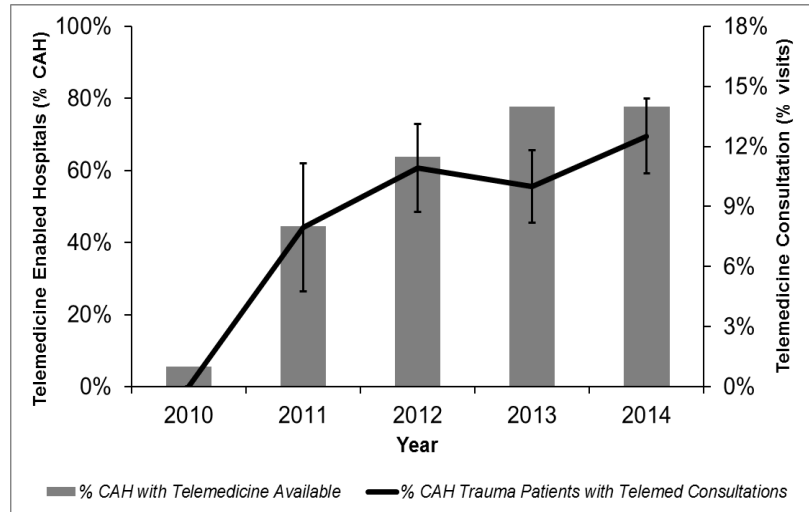


Figure 1. Telemedicine utilization over time in North Dakota critical access hospital (CAH) emergency departments (EDs), 2010-2014. Grey bars represent the proportion of CAH EDs in North Dakota with active telemedicine subscriptions (left axis). The black line represents the proportion of all trauma patients treated in telemedicine-capable North Dakota CAH EDs who had telemedicine consultation (right axis). Error bars represent 95 percent confidence intervals.

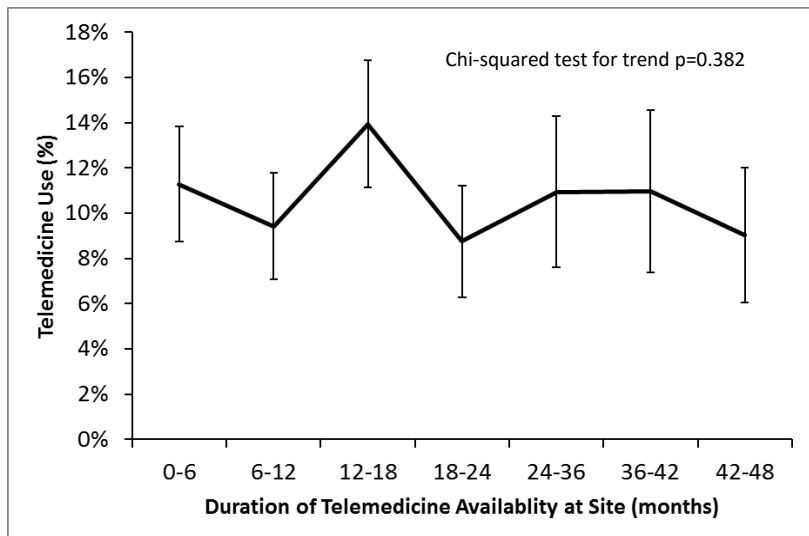


Figure 2. Telemedicine consultation in North Dakota critical access hospital emergency departments by the duration telemedicine has been available at the visit site. All visits were classified by the duration of time telemedicine had been available at the site where the visit occurred. There was no significant change in telemedicine usage over time ($p = 0.382$). Error bars represent 95 percent confidence intervals.

Trends in Trauma Telemedicine Usage. Consultation rates for trauma patients ranged from 2 percent for the lowest-utilizing hospital to 56 percent for the highest-utilizing hospital. The proportion of all trauma patients in telemedicine-capable North Dakota CAHs who had telemedicine consultation increased over time (Figure 1). This increased utilization was attributable primarily to telemedicine subscription by higher utilizing centers, since telemedicine use within individual facilities did not change over the study period (Figure 2).

Factors Associated with Telemedicine Subscription. Because telemedicine penetration changed over the study period, hospital-level factors associated with telemedicine implementation were analyzed based on data from July 1, 2012 (when approximately half of eligible CAHs had subscribed). No hospital-level factors were identified that were associated with early adoption of telemedicine (Table 1).

Table 1. Factors associated with telemedicine subscription in critical access hospitals in North Dakota

Hospital Factor ^a	Telemedicine Subscription (n = 22)	No Telemedicine Subscription (n = 13)	p-value ^b
Annual number of trauma cases, mean (SD) ^c	37.0 (41.9)	56.7 (68.7)	0.346
Number of inpatient acute care beds, mean (SD) ^c	22.0 (3.7)	22.1 (5.2)	0.463
Rurality: Isolated rural, n (%)	16 (73%)	9 (69%)	0.209
Trauma center designation			0.999
Level IV, n (%)	4 (18%)	2 (17%)	
Level V, n (%)	18 (82%)	10 (83%)	
Total annual hospital inpatient days, mean (SD) ^c	6,057 (6,315)	8,745 (10,103)	0.773
Emergency department visits, mean (SD) ^c	3,675 (4,100)	3,629 (4,611)	0.577
Miles to level II trauma center, mean (SD) ^c	93.5 (32.0)	74.2 (31.5)	0.118

^aHospital factors are based on Avera eEmergency subscription status on July 1, 2012.

^bStatistical comparison was performed using univariate multilevel regression, clustered on presenting hospital.

^cStandard deviation.

Factors Associated with Trauma Telemedicine Use. Among hospitals that subscribed to ED-based telemedicine services, no hospital-level factors were associated with telemedicine use (Table 2).

Table 2. Factors associated with trauma telemedicine use in telemedicine-capable critical access hospital emergency departments in North Dakota

Hospital Factor ^a	Telemedicine Used (n = 361)	Telemedicine Not Used (n = 2948)	p-value ^b
Annual number of trauma cases, mean (SD) ^c	114.7 (89.8)	119.0 (84.5)	0.529
Number of inpatient acute care beds, mean (SD) ^c	23.7 (2.4)	24.3 (2.0)	0.263
Hospital rurality			0.583
Urban, n (%)	6 (1.7%) ^d	34 (1.2%)	
Large rural, n (%)	138 (38.2%)	1,124 (38.1%)	
Small rural, n (%)	48 (13.3%)	571 (19.4%)	
Isolated, n (%)	169 (46.8%)	1,219 (41.4%)	
Trauma center designation			0.354
Level IV, n (%)	160 (44.3%)	1,349 (45.8%)	
Level V, n (%)	201 (55.7%)	1,599 (54.2%)	
Total annual hospital inpatient days, mean (SD) ^c	6,179 (6,430)	5,270 (5,795)	0.565
Emergency department visits, mean (SD) ^c	8,999 (6,429)	9,262 (6,139)	0.363
Miles to level II trauma center, mean (SD) ^c	102.4 (27.4)	101.6 (27.3)	0.506

^aHospital factors are based on Avera eEmergency subscription status on July 1, 2012.

^bStatistical comparison was performed using univariate multilevel regression, clustered on hospital. The p-value used to compare the characteristics of those hospitals where telemedicine was used vs. where it was not used. If p>0.05, there was no statistical difference in the parameter.

^cStandard deviation.

^dAll percentages refer to proportion of column total (for instance, proportion of all cases in which telemedicine was used in which the hospital was classified as “small rural,” by RUCA code).

Discussion

Telemedicine availability has revolutionized rural emergency care and regionalization, and in some regions telemedicine adoption has been rapid and ubiquitous. Trauma is a common indication for telemedicine utilization,⁵ and it may be a condition where telemedicine influences clinical care and outcomes. Perhaps surprisingly, hospital-level factors and geographic factors do not influence either the penetration or the use of telemedicine.

Perhaps this study's most relevant finding is that telemedicine growth in North Dakota has been rapid and that 81 percent of North Dakota CAHs now subscribe to tele-ED services. We also observed that within hospitals, telemedicine use is stable. Although utilization between hospitals varies, the consultation rate is sustained once it is integrated into standard medical practice. This finding may relate to the perceived value by end users, because if telemedicine did not offer significant perceived value, its use might be expected to decline after an initial period of enthusiasm. For trauma patients in North Dakota CAH EDs, however, activation of the telemedicine network remains consistent.

One reason that hospital-level and geographic factors do not explain subscription or use in this study may be that North Dakota CAHs have similar medical capabilities between hospitals. No prior reports have suggested that telemedicine has led to changes in North Dakota ED staffing or specialist availability, so even though there is variation in technical capabilities across North Dakota hospitals, it may not lead to changes in telemedicine subscription or usage. Additional patient or injury factors may better describe variation in telemedicine use.

An important consideration in understanding ED telemedicine subscription and usage is the mechanism by which telemedicine might influence rural trauma care. Prior studies have reported increases in medical staff comfort and improved recruitment and retention of rural physicians with the availability of telemedicine services.^{6,7} Qualitative studies have cited that telemedicine providers' assistance in arranging transfer, providing specific technical support, and advising rural providers on care are perceived as being of particularly high value. These telemedicine services may also help deliver trauma care faster and more efficiently. This study is limited by its observational design and by the hospital-level characteristics available in the American Hospital Association data set.

In conclusion, telemedicine availability and use is increasing in rural EDs, serving 10.9 percent of injured residents at North Dakota telemedicine-capable hospitals from 2008 to 2014. Once implemented, telemedicine use is sustained within institutions, and hospital and geographic factors do not describe variability in use.

Notes

1. Ten Leading Causes of Death by Age Group, United States - 2013. Atlanta, Georgia: National Center for Injury Prevention and Control (CDC); 2013.
2. Peek-Asa C, Zerling C, Stallones L. Acute traumatic injuries in rural populations. *Am J Public Health*. 2004;94(10):1689-1693.
3. Carr BG, Branas CC, Metlay JP, Sullivan AF, Camargo CA, Jr. Access to emergency care in the United States. *Ann Emerg Med*. 2009;54(2):261-269.
4. Mueller KJ, Potter AJ, MacKinney AC, Ward MM. Lessons from tele-emergency: improving care quality and health outcomes by expanding support for rural care systems. *Health Aff (Millwood)*. 2014;33(2):228-234.
5. Ward MM, Ullrich F, MacKinney AC, Bell AL, Shipp S, Mueller KJ. Tele-emergency utilization: In what clinical situations is tele-emergency activated? *J Telemed Telecare*. 2016;22(1):25-31.
6. Ward MM, Ullrich F, Potter AJ, MacKinney AC, Kappel S, Mueller KJ. Factors affecting staff perceptions of Tele-ICU service in rural hospitals. *Telemed eHealth*. 2015;21(6):459-466.
7. Potter AJ, Mueller KJ, MacKinney AC, Ward MM. Effect of tele-emergency services on recruitment and retention of US rural physicians. *Rural Remote Health*. 2014;14(3):2787.

This study was supported by the Federal Office of Rural Health Policy (FORHP), Health Resources and Services Administration (HRSA), U.S. Department of Health and Human Services (HHS) under grant number 6 UICRH29074-01-01. The information and conclusions in this brief are those of the authors and no inferred endorsement by FORHP, HRSA, or HHS.

R H R C
Rural Health Research
& Policy Centers

Funded by the Federal Office of Rural Health Policy
www.ruralhealthresearch.org