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Technical Communication and Clinical Health Care:

Improving Rural Emergency Trauma Care Through Synchronous Videoconferencing

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accepted
J of Technical Writing and
Communication 2003

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Abstract: *While debates continue over the effectiveness of innovative communication technologies to bring information and services to populations that have been underserved by such new technologies, a federally-funded program at the University of Vermont and Fletcher Allen Health Care (FAHC), Burlington, VT has enabled trauma specialists to link with rural emergency room health care providers through a synchronous videoconferencing (telemedicine) network. Analysis of the FAHC trauma registry data shows that three of the four hospitals had a shorter time between injury at the accident scene and arrival at FAHC for tele-trauma patients, the length of stay of tele-trauma patients was not significantly longer than length of stay for direct admission trauma patients, there was no difference in mortality between tele-trauma and direct admission patients, and tele-trauma patients had fewer complications than direct admission patients during their stay at FAHC. However, none of these finding were statistically significant due to low sample size. Surveys completed by the participating physicians after each use of the computer conferencing system as well as interviews and observations indicate that the FAHC consulting trauma specialists and the remotely located physicians felt the linkups do not interfere with standard ER procedures, that communication was at least adequate for all consultations, and that the consults improved the quality of care for over half of the cases. Furthermore, interviews with rural ER physicians indicated that they saw the program operating as the first stage of FAHC's management of a patient to be transferred to that facility.*

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One of the most important pro-social promises of computer-based communications is increased access to information and services that span distance and demographics. In this oft-hyped ideal, electronic networks will create new opportunities for populations who have historically lagged in benefiting from the fruits of new technological developments. In contrast, an equally-hyped counter to that democratizing ideal is that the new networks will merely reinforce existing imbalances in social, economic, and educational opportunities, creating a "digital divide" that actually widens the gap between economic and educational "haves and havenots."

Is it possible to know whether or not these network technologies are benefiting heretofore underserved populations? When asked broadly, we can find data that supports either side of the issue. For example, two recent well-publicized studies of Internet use have concluded that the digital divide is disappearing. A study by the UCLA Center for Communication Policy found that in 2001 Internet use is rising at a dramatic rate across the population regardless of the users' levels of education (UCLA Internet Report 2001). A Pew Research Center study showed that from 1998 to 2000 the percentage of women and African-Americans using the Internet increased at significant rates although both populations' usage still lagged behind that of white males (Internet and American Life).

Furthermore, the Bush Administration in 2002 has recommended cutting the 2003 federal budget for programs aimed at reducing the digital divide.

In contrast, the Benton Foundation through its Digital Divide Network in conjunction with a variety of social service organizations continue to argue that studies such as these do not show a disappearing digital divide and in fact they reveal a staggering gap in access for many populations both in the US and around the world (Digital Divide Basics Fact Sheet)

While arguing this question on such a large scale has potential benefits and the answers will certainly enhance or inhibit federal support for programs designed to bridge the divide, another approach to answering this question is to examine the success or failure of specific applications that are designed to increase access to socially beneficial information and services. This article reports on one such study: it assesses the utility of computer-based networking designed to increase access to potentially crucial, even life-saving health care expertise for an underserved population.

Historically, rural hospitals have less access to the expertise of medical specialists who typically are clustered in urban health care complexes. To address this problem in one rural region the U.S. Department of Commerce's Technology Opportunities Program has funded a program that supports the use of a computer conferencing (telemedicine) system to enhance health care provided to emergency trauma victims in a rural region across parts of Vermont and northern New York (Rogers, Ricci, et al).

A Life and Death Problem: Access to Emergency Trauma Expertise

Although only one third of the population of the United States resides in rural areas, over one half of deaths due to motor vehicle accidents occur in rural areas.

(Congressional Office of Technology Assessment). In fact, both adults and children die at nearly twice the rate of their urban counterparts from vehicular accidents, homicides, falls, and suicides (Norwood and Myers).Yet, trauma centers—health facilities staffed with trauma specialists that can offer the highest levels of care and lower mortality rates for trauma victims—are concentrated in urban areas.

Fletcher Allen Health Care (FAHC), located in the largest city in Vermont, Burlington, is the only Level One trauma center—the highest rating for a trauma center—serving Vermont and Northeastern New York . Victims of trauma across this region cannot take advantage of the specialties and skills of the staff at the trauma center until those victims are physically transferred to FAHC by ambulance or helicopter. Emergency Departments across the region are staffed by health care providers who are not specially trained in the care of the multi-trauma patient, particularly the injured child. Long transport times to the trauma center, particularly in winter, can delay significant and life-saving care (Norwood and Myers).

Although tele-trauma programs are relatively recent, there is some evidence that such technologies can benefit trauma patients through better communication between consultants and providers on the nature of the trauma and more efficient decisions on whether or not patients need to be transferred to the trauma centers (Aucar et al; Bowater). Furthermore, diagnoses arrived at through tele-trauma can be accurate and effective (Lambrecht; Tachakra, Loane, and Uche; Tachakra, Lynch, et al).

Previous studies also indicate that for a tele-trauma application to succeed those who design such an application must take into account key personnel issues, such as staff training, technical support, and participant attitudes toward the tele-trauma technology as

well as key communication infrastructure issues such as cameras, lighting, room layouts, video and sound quality and the like (Tachakra, Lynch, et al; Tachakra, Sivakumar, et al).

At the FAHC Trauma Center, as many as 40-60% of both adult and pediatric patients treated are transferred in from outlying facilities (Vane and Shackford; Rogers, Osler, et al). Although it would seem intuitive that patients transferred from rural settings are those that are most critically ill, this is not always the case. The most frequent reason for these transfers is the lack of personnel or resources at the local facility (e.g., surgeon, ICU, blood bank, or specialty care) (Cone). In a study from FAHC, patients transferred to Burlington were very similar to those admitted directly; time to definitive care was high for rural trauma patients; patients spent an average of three hours in local emergency rooms prior to transfer to the trauma center; and patients also spent an additional hour or more in transport from one facility to another (Rogers, Osler, et al). At least one study has suggested that telemedicine can reduce these times (Messick, et al).

The Project: Access to Tele-Trauma Technology and Expertise

This project involved partnerships between the University of Vermont College of Medicine and FAHC, and four rural hospitals: Copley Hospital in Morrisville, VT, Canton-Potsdam Hospital in Potsdam, NY, Alice Hyde Hospital in Malone, NY and Massena Memorial Hospital in Massena, NY.

Vermont, 49th in the US in population, has the largest percentage of its population (68%) living in rural areas. In NY, the 1990 census lists the population of St. Lawrence County which Massena Memorial Hospital and Canton-Potsdam Hospital serve at 111,974 and Franklin County which Alice Hyde Hospital serves at 46,540. The region served by this project is clearly rural.

Travel distance from the partner hospitals to the Trauma Center is as much as 160 miles. The Green Mountains, Adirondack Mountains, and Lake Champlain are natural barriers. In addition, severe weather much of the year can also delay transport efforts. Roads can be difficult to travel, especially in the winter months (1 of the 2 major roads into Morrisville, VT is closed with the first snowfall each November). None of the hospitals has direct highway access to Burlington. Though helicopter transport might be perceived as a way to improve transportation, in fact added time to assemble a volunteer squad (in NY State) or to fly from out of State (VT has no instate helicopter service) can negate faster flight times. In addition, weather conditions in our region can prohibit transport by air up to 30% of the time.

In order to address these access problems for rural patients and providers this project provided twenty-four hour access to tele-trauma consults from adult and pediatric trauma surgeons, as well as vascular surgeons, at the FAHC Trauma Center via interactive video workstations in the Trauma Center and the surgeons' homes. FAHC has in place the infrastructure to provide trauma care and education utilizing a state-of-the-art interactive video telemedicine system (Ricci et al). In this way, patients have the benefit of the experience and expertise that comes with the trauma center as well as the application of standardized trauma protocols from the moment they enter a hospital. It is this time factor that is most critical since the care delivered immediately after trauma (the so-called "golden hour") is the most significant factor relating to survival (Mueller et al).

The system was designed so that its use would not require the rural hospitals to do anything other than initiate a phone call to activate the system. When, for example, an ambulance is enroute to the rural hospital from an accident site, a single call would be

placed by the rural Emergency Department to FAHC. By the time the patient is brought into the rural ER, the specialist at FAHC would already be connected to the dedicated computer conferencing unit in the rural ER. The FAHC specialist remotely controls the camera and microphones mounted in the rural ER while simultaneously appearing on the screen in the rural ER. The intention of this design is that the specialist would then be able to observe the patient, listen to the remote ER procedures, and consult as needed with the attending provider while that provider focuses on the patient and not on the communication technology. The rural provider would not need to make a phone call as typically happens in non-tele-trauma cases to discuss a difficult case with a remotely located trauma specialist. If the patient is later transferred to FAHC, the case would already be familiar to the FAHC trauma center enabling a greater continuity of patient care from one institution to the other.

Assessment Objectives and Methods

Two domains were evaluated: clinical outcomes and participant acceptability.

Clinical outcomes were assessed by evaluating the usefulness of immediate connection to the trauma specialists via synchronous computer conferencing by 1) developing descriptive data of the tele-trauma cases , 2) establishing the relative severity of each patient's injuries (through the Injury Severity Score, ISS; see Baker et al) and each patient's outcome (the patient's complications, length of stay, and survival), and 3) correlating these data in trauma patients who were managed through the tele-trauma program with those patients managed without tele-trauma. These data were made available through the FAHC Trauma Registry.

Every patient entering a trauma center is assigned an ISS score that quantifies the level of injury and this score is collected in the FAHC Trauma Registry. Accordingly, every patient in this project who was transferred to FAHC was assigned an ISS score. This allowed for the comparison of outcomes in comparably injured patients. A few prior studies of telemedicine use in trauma have documented that its use can reduce adverse events, improve transportation times (Messick et al), and help keep more patients in their local hospitals (Goh et al). (For an explanation of data analysis procedures, see the Appendix.)

Participant Acceptability was assessed by recording participating physicians' perceptions of the usability of the technology, confidence in the diagnosis and value of telemedicine assistance, and efficiency of telemedicine through survey questionnaires administered after each tele-trauma transaction. In addition, interviews and on-site observations of rural ER tele-trauma facilities were conducted at two of the hospitals.

Results

Clinical outcomes involve 1) descriptive data of tele-trauma consultations, and 2) comparisons of tele-trauma patients to non-tele-trauma patients from Trauma Registry data.

Participant Acceptability involve 1) the evaluative assessments of the tele-trauma consultations from both the providers and the consultants as collected by questionnaires administered after the transaction, and 2) the evaluative assessments collected at two sites through a site visit by one of the project evaluators.

Clinical Outcomes Pt. 1: Descriptive data about trauma tele-trauma consultations

- Twenty-eight (28) telemedicine trauma consultations occurred between 5 April 2000 and 29 June 2001.
- Twenty-one of the patients (75%) were transferred from the rural hospital to FAHC.
- Patients ranged in age from 14 to 81 years old.
- The most common injuries encountered in the tele-trauma group were closed head injuries, long bone fractures, and chest injuries caused by a variety of motor vehicle accidents.
- The most common questions asked by referring providers related to options for head injuries and airway (breathing) treatments. Other questions related to necessity for transfer and availability of specialists.
- According to the trauma specialist at FAHC, the advice given included:

  Send patient to FAHC - routine – 4 patients (14%)

  Send patient to FAHC - ASAP – 15 patients (54%)

  There were seventeen other types of advice all of which involved clinical treatment, such as "place chest tube" and "give blood."

  The survey responses from the rural referring provider indicate that in three instances the referring provider said that particular advice was given while the trauma surgeon did not indicate that advice had been given: For example, there

were two cases where the referring provider listed "Send to FAHC – ASAP" but the consulting surgeon listed "Send to FAHC – routine."

Clinical Outcomes Pt. 2: Comparison of Tele-trauma Patients and Non-Tele-trauma Patients from Trauma Registry data.

Number of patients and injury severity

- Nineteen (19) tele-trauma patients transferred to FAHC during April 2000-June 2001. (Data from the other two patients transferred to FAHC were not in the trauma registry.)
- Three hundred and ninety-six (396) other patients listed in trauma registry for same time period but not seen via telemedicine were transferred to FAHC from 24 hospitals in Vermont and upstate New York
- Tele-trauma and non-tele-trauma trauma patients differed significantly for injury severity. Those patients seen via the tele-trauma system had a mean injury severity score that was approximately twice that of the patients who were not a part of the tele-trauma program. Because of the injury severity differences, most analyses were restricted to only those patients with ISS in the range of the ISS for the tele-trauma patients. There were 266 non-tele-trauma patients with ISS in this range. Even within this range, tele-trauma patients had a higher ISS score than non-tele-trauma patients. Thus, it was necessary to adjust for injury severity in the analyses presented below.

Time between injury and arrival at FAHC

- Three of the four hospitals had a shorter time between injury and arrival at FAHC for tele-trauma patients; however, this difference was not statistically significant. The small sample size limits the power to detect differences between the groups.

Length of stay at FAHC

- Length of stay of tele-trauma patients was nonsignificantly longer than length of stay for non-tele-trauma patients

Mortality rate

- There was no difference in the rate of mortality between tele-trauma and non-tele-trauma patients.

Complications at FAHC

- Tele-trauma patients had fewer complications than non-tele-trauma patients during their stay at FAHC, but the difference was not statistically significant.

Participant Acceptability Pt. 1: Survey Results

Survey results indicate that the consulting specialists at FAHC and referring providers at the rural hospitals

- believed that the consults improved the quality of care for over half of the cases,

  FAHC specialist: 63% Strongly Agree or Agree

  Rural provider: 83% Strongly Agree or Agree

- did not believe that the consult could have been performed as well by telephone,

  FAHC specialist: 60% Strongly Agree or Agree

Rural provider: 64% Strongly Agree or Agree

- believed that the ease of use of the equipment was usually at least adequate,

  FAHC specialist: 79% Very Good, Good, or Adequate

  Rural provider: 75% Very Good, Good, or Adequate

- believed that the video quality overall as slightly better than audio quality, and

  FAHC specialist: 66% video Very Good, Good

  50% audio Very Good, Good

  Rural provider: 84% video Very Good, Good

  75% audio Very Good, Good

- believed that communication was at least adequate for all consultations.

  FAHC specialist: 100% Very Good, Good, or Adequate

  Rural provider: 100% Very Good, Good

In a few cases the consulting and referring providers rated some items rather differently. When asked if the transaction "could have been performed as well by telephone," in one case the consultant agreed and the referrer disagreed while for two cases the referrer agreed and the consultant disagreed. For the "ease of use of the equipment" question, in two cases the consultant responded "very good" while the referrer responded "poor" or "very poor," while for three cases the referrer put "very good" or "good" but the consultant put "poor".

There were two cases where the video quality was rated good or very good for the referrer but poor or very poor for the consultant, and three cases where the audio quality

was rated good for the referrer but poor or very poor for the consultant. These discrepancies may indicate that the transmission quality indeed did differ on one end of the transaction. It can also indicate that the consultant is more focused on the transmission quality because that represents the entire experience for the consultant while the rural provider is primarily focused on the patient in the ER while only listening to the consultant's voice through the system. In particular, if the video quality of the "talking head" at FAHC was less than ideal for the rural physician, that physician may not even notice or care.

The overall conclusion that telemedicine is an adequate positive addition to trauma care were complemented by the results of the on-site interviews and observations.

Participant Acceptability Pt. 2: Selected On-site Interviews and Observations.

The two sites that implemented the majority trauma tele-consults—Alice Hyde Hospital, Malone, NY and Massena Memorial Hospital, Massena NY—were visited. At Alice Hyde the head ER surgeon and two ER nurses were interviewed. At Massena one of the principal ER surgeons and the head ER nurse were interviewed. The key findings were:

- When the telemedicine system worked as designed, it did not interfere with standard ER procedures and the consultant could interact with the ER personnel clearly and effectively.
- The program was perceived by the remote staff as the first stage of FAHC's management of a patient to be transferred. At the time of the interviews no patients were kept from transferring as a result of the tele-consults.

- The system operated with little or nothing for the ER staff to do; therefore, it did not interfere with standard procedures.
- The interaction between surgeon and consultant was clear and concrete, with quick bits of dialogue during the session.

Discussion and Conclusion

The impact of the tele-trauma system is hard to quantify. Most consults proceeded in a collegial fashion with both physicians jointly caring for the patient cooperatively. The consults from the trauma center were not paternalistic nor didactic. All parties involved developed a healthy respect for each other and worked to provide the best possible care in a timely fashion. Perhaps the most telling and practical aspect of this study is the statement by physicians who felt the tele-trauma consult improved the care of the patient.

Overall, then, there was a nonsignificant trend towards the tele-trauma patients having a shorter time between time of injury and arrival at FAHC. Tele-trauma might be expected to have an impact on this interval, since the consultation with the referring site occurs sooner than when technology is not used. There was no difference in transport time from the referring hospital to FAHC, which is also reasonable—tele-trauma would not be expected to affect this time interval.

Length of stay upon arrival at FAHC was nonsignificantly longer for the patients seen via tele-trauma. The reason for this is not clear, since tele-trauma consultation would not be expected to directly impact care once the patient arrived at FAHC. The

difference may be due to chance, or may be due to incomplete control of differences in injury severity.

Mortality did not differ for the tele-trauma and non-tele-trauma patients, but there was a nonsignificant trend toward fewer complications in the tele-trauma patients. The earlier time of consultation and the shorter interval between injury and arrival at FAHC both could contribute to fewer complications. However, the difference observed in this study might simply be due to chance.

For specific types of complications and outcomes other than death, the sample sizes were too small for meaningful comparisons.

The primary limitation of this study is that the number of tele-trauma consultations was much smaller than anticipated, which resulted in low power to detect any computer conferencing effect. Another limitation is that the tele-trauma patients were more severely injured than the non-tele-trauma patients, even after restricting the non-tele-trauma patients to those with ISS scores in the same range as the tele-trauma patients. Although ISS was adjusted for in the analyses, residual confounding was still possible. This would lead to an underestimation of the benefits of telemedicine.

The program provided continuity of care for the patient. These sessions served primarily as the beginning of FAHC's management of the case since most cases were transferred. The calls were made when transfer seemed assured. This enabled FAHC to know ahead of time the key information about the patient who would be arriving. This shifted responsibility toward FAHC; if the consultant suggested for the ER physician to do or not do X, then the burden was shifting to the consulting physicians. Most importantly the program replaced after-transfer phone calls between the rural ER and

FAHC that are normally necessary because FAHC has not yet seen the patient. That was changed in this program and potential misperceptions that could arise during verbal phone discussions were eliminated. This saved time and improved patient care.

Does the new communication technology bring benefit to an underserved population? The answer is a qualified yes. The grant funding for the FAHC teletrauma program has ended. With the support of the trauma surgeons, the teletrauma program has shifted from grant funding to hospital funding. Additional grant funds are being sought to add more rural hospitals and surgeons' homes, but the existing project has been absorbed as part of the cost of being a level one trauma center. It will be up to similar institutions to decide whether or not the benefits outweigh the costs to run such a system—especially if government support for such programs decreases.

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Appendix: Trauma Registry Data Analysis Procedures

Bivariate comparisons between tele-trauma and non-tele-trauma patients were conducted using Fisher's exact test, *t* tests, or Wilcoxon rank sum tests, depending on the type of variable. Because tele-trauma patients were on average more severely injured, some analyses were restricted to patients with injury severity score (ISS) within the range of those for the tele-trauma patients. In addition, the multivariable methods of analysis of covariance and multiple logistic regression were used to adjust for differences in injury severity as measured by ISS.