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Telemedicine Versus Emergency Transfer of Trauma Patients: A Systematic Review

Jason Olson

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Telemedicine Versus Emergency Transfer of Trauma Patients: A Systematic Review

Abstract

Background: There are disproportionally high rates of traumatic injuries in rural populations with high rates of mortality. Rural trauma patients are more likely to be transferred to a Level 1 trauma center for definitive care than are trauma patients in urban settings. Telemedicine offers the ability to bring the trauma center to the rural patient allowing advanced assessment, resuscitation, and disposition at the local community hospital. Through the means of telemedicine, the number of trauma transfers can be reduced which will in turn reduce costs to the healthcare system while improving patient care.

Methods: A comprehensive search was performed using multiple databases including: Medline-OVID, Medline-PubMed, Web of Science, and Google Scholar. The following MESH terms and keywords were used in combination for this search: emergency service, trauma, rural, rural hospital, telemedicine, telepresence, transport, cost, and cost analysis. Each study found in the initial search was screened for eligibility criteria as well as citations for more relevant articles.

Results: Of the 20 studies found in the search, 3 met the eligibility criteria for this review. Each study demonstrated the ability of telemedicine to allow local community hospitals to assess and treat trauma patients and negate the need for transfer to a trauma center. Duchesne et al saw an 89% decrease in the number of trauma transfers, and Latifi et al and Rogers et al avoided transfers in roughly 23% of patients. Latifi et al estimated cost savings from transports alone was as high as $203 952 over 4 years, while Duchesne et al showed total hospital costs could be reduced by approximately $6.5 million over 5 years. As technology has advanced, so has the cost, and the budget for implementing a telemedicine program was reported to be as low as $10 000 per facility by Rogers et al.

Conclusion: Extrapolation of current studies shows that telemedicine may be an effective alternative to emergency transfers of trauma patients from remote community hospitals to trauma centers. This allows for early definitive care at the local hospital with the guidance of a specialist at the trauma center. As the cost of transferring patients increases and the cost of technology decreases it may become financially beneficial for healthcare systems to implement telemedicine programs.

Keywords: Telemedicine, telepresence, rural populations, rural hospitals, trauma, trauma transfers, emergency transports, cost.

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Degree Name
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Keywords
emergency service, trauma, rural, rural hospital, telemedicine, telepresence, transport, cost, and cost analysis

Subject Categories
Medicine and Health Sciences

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Telemedicine Versus Emergency Transfer of Rural Trauma Patients: A Systematic Review

Jason Olson

A Clinical Graduate Project Submitted to the Faculty of the

School of Physician Assistant Studies

Pacific University

Hillsboro, OR

For the Masters of Science Degree, 08/09/2014

Faculty Advisor: Robert Rosenow, Pharm. D., O.D.

Clinical Graduate Project Coordinator: Annjanette Sommers, PA-C, MS
Biography
Jason Olson was raised in a small farming community rural Oregon. He attended Portland State University where he graduated cum laude with a bachelor of exercise science. After working as a lifeguard, physical therapy aide, and EMT he gained acceptance into Pacific University’s Physician Assistant program. Upon acceptance he enrolled in the inaugural class of the Rural Track Program, traveled with the Nicaragua Interdisciplinary Project, volunteered with the Interdisciplinary Diabetes Clinic, and was the first PA student to be awarded the Primary Health Care Loan Forgiveness scholarship through the Oregon Office of Rural Health.
Abstract

Background: There are disproportionally high rates of traumatic injuries in rural populations with high rates of mortality. Rural trauma patients are more likely to be transferred to a Level 1 trauma center for definitive care than are trauma patients in urban settings. Telemedicine offers the ability to bring the trauma center to the rural patient allowing advanced assessment, resuscitation, and disposition at the local community hospital. Through the means of telemedicine, the number of trauma transfers can be reduced which will in turn reduce costs to the healthcare system while improving patient care.

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Conclusion: Extrapolation of current studies shows that telemedicine may be an effective alternative to emergency transfers of trauma patients from remote community hospitals to trauma centers. This allows for early definitive care at the local hospital with the guidance of a specialist at the trauma center. As the cost of transferring patients increases and the cost of technology decreases it may become financially beneficial for healthcare systems to implement telemedicine programs.

Keywords: Telemedicine, telepresence, rural populations, rural hospitals, trauma, trauma transfers, emergency transports, cost.
Acknowledgements

[Redacted for privacy]
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List of Abbreviations

ED.................................................................Emergency Department
FAHC..............................................................Fletcher Allen Health Care
GCS.................................................................Glasgow Coma Scale
ISS.................................................................Injury Severity Score
LCH.................................................................Local Community Hospital
LOS..............................................................Length of Stay
MOI.................................................................Mechanism of Injury
MVC.................................................................Motor Vehicle Collision
RTS.................................................................Revised Trauma Score
TC.................................................................Trauma Center (level 1)
TM.................................................................Telemedicine
TT.................................................................Transfer Time
SATT.............................................................Southern Arizona Telemedicine and Telepresence
UMC.............................................................University Medical Center
UVM.............................................................University of Vermont
BACKGROUND

Injury is the most common reason for emergency department (ED) visits for individuals 18 years and older and the second most common reason for those younger than 18 years of age.\textsuperscript{1} Furthermore, trauma, specifically unintentional injury, is by far the leading diagnosis of ED visits for all persons, and unintentional injury is the fifth leading cause of death for all persons and the third leading cause for males.\textsuperscript{1} Rural areas are known to have disproportionally higher rates of traumatic injuries, as well as higher mortality than urban populations.\textsuperscript{1,2} Death rates from motor vehicle collisions (MVC) alone are 3 times higher in rural populations.\textsuperscript{3} And rural professions such agriculture and mining are first and second, respectively, in regards to deaths rates due to fatal injury by occupation.\textsuperscript{1}

Based on vitals signs it is estimated that up to 20\% of rural deaths are possibly preventable compared to 9\% of urban deaths.\textsuperscript{3} In contrast, when comparing rural to urban on scene death rates, the incidence is equal.\textsuperscript{3} One major factor for the higher mortality rates in rural areas is the increased time required to reach definitive care.\textsuperscript{3,4} Level 1 trauma centers (TC) with 24-hour surgeon subspecialty (eg, trauma, cardiac, orthopedic and neurosurgery) coverage are typically located in urban settings. Local community hospitals (LCH) are typically less experienced and less equipped for high acuity traumatically injured patients. This is evident by the fact trauma patients injured in
a rural setting are 4 times more likely to be transferred to a TC than urban trauma patients. Rural populations are also less likely to have medical insurance. This equates to rural trauma patients adding financial burdens onto the healthcare system.

One way to bridge this gap and bring more definitive care for rural trauma patients from an urban TC to a remote LCH, thereby reducing the number of transfers is through the use of telemedicine (TM). Currently, telemedicine is the use of two-way video, audio, and imaging technology to communicate between healthcare facilities, offering a live view of the patient from practically any length of distance. Preliminary results show telemedicine offers the ability to bring the knowledge and expertise of the TC to the LCH in real time to aid in assessment, resuscitation, procedures and disposition of the trauma patient. Published narratives have demonstrated that telemedicine, when used for consults of acute trauma patients, increases the ability of the LCH to manage the patient, thus negating the need to transfer the patient to a TC for definitive care. With advancements in affordable technology, the setup costs of telemedicine systems has reduced to the point that it may offer an affordable alternative to emergency air/ground transports between hospitals.

Whitten et al performed a systematic review of the cost effectiveness of telemedicine interventions published in 2002, and concluded it was not a cost effective means of delivering healthcare. However, this systematic review aims to find objective analysis from more recent studies performed using telemedicine for trauma patients in rural populations, to see if they truly reduce the number of transferred patients, and to determine if this equates to reduce costs to the healthcare system.
METHODS

A comprehensive search was performed using multiple databases including: Medline-OVID, Medline-PubMed, Web of Science, and Google Scholar. The following MESH terms and keywords were used in combination for this search: emergency service, trauma, rural, rural hospital, telemedicine, telepresence, transport, cost, and cost analysis. Each study found in the initial search was screened for eligibility criteria as well as cited materials for more relevant articles.

Inclusion criteria for this systematic review included studies that focused on the impact of telemedicine on trauma patients. Studies needed to address the cost of transporting patients, evaluate the cost of implementing a telemedicine system, or compare the effect of telemedicine on the number of transports performed. Studies were also required to be on humans and written in English. Exclusion criteria for this systematic review included studies published in abstract form only. Studies appraising telemedicine for follow up care. Studies involving telemedicine for specialties other than trauma (eg, psychiatry, cardiology, pediatrics etc) were not included. Results were further narrowed to studies performed after the year 2000 for technological relevance.

RESULTS

The initial search resulted in 13 studies of which three met criteria for this systematic review. All cohort studies were assessed for methods used determine to pre- and post telemedicine transports including retrospective data collection, as well as study length, population size and cost analysis.
Duchesne et al\textsuperscript{16} performed a 5-year cohort study of trauma patients in Mississippi that included a 2.5-year retrospective cohort data collection of pre-telemedicine (TM) trauma patients. The TM program in Mississippi began as a grant and included seven rural local community hospitals (LCH) and the University of Mississippi Medical Center, which is the only trauma center (TC) in the state. Data collection included patient demographics, injury severity score (ISS), vital signs, number of transfusions, volume and mode of transports, length of stay (LOS), transfer time (TT), TC mortality, and hospital cost.\textsuperscript{16}

During the study period there were a total of 814 trauma patients (351 pre-TM and 463 post-TM). In the pre-TM era all trauma assessments performed at the LCH level were done without TC support, and it was the decision of the primary practitioner to call for transfer to the TC. During this time 351 of 351 (100\%) patients were transported to the TC via air or ground emergency services (see figure I).\textsuperscript{16}

In the post TM era the initial trauma assessment was performed in the same fashion but included a teleconsult with the TC, which was performed either simultaneously or immediately after the initial assessment. There was a total of 463 teleconsults performed during the study and 51 (11\%) were transferred to the TC, 284 (61.3\%) were discharged home, 63 (13.6\%) were admitted to the LCH, 15 (3.2\%) left against medical advice (AMA), 5 (1.1\%) was transferred to another LCH, and 44 (9.5\%) didn’t have sufficient data (see figure II). Although there was a statistically significant difference in percentage of transfers 100\% versus 11\%, there was no difference in mode of transfer. Ground transfer via ambulance was 263 (74.9\%) in the pre-TM group and 36
(70.5%) in the post-TM group. While there was 83 (23.6%) and 15 (29.4%) air transfers in the pre-TM and post-TM groups, respectively.\textsuperscript{16}

Hospital costs compared in the two groups was defined as “total hospital charges” for patients who were transferred to the TC from a LCH during both pre- and post-TM periods.\textsuperscript{16} TC hospital costs during the pre-TM period was approximately $7.6 million, and during the post-TM period was $1.1 million, which resulted in a difference of $6.5 million. Though the average cost per trauma patient actually increased from $21 745 for pre-TM to $22 091 post-TM, the post-TM group had higher injury severity scores (ISS), higher incidence of penetrating injury, and higher need for transfusions. Despite this there was no statistically significant difference in mortality between the two groups \textsuperscript{17} (4.8%) and 4 (7.8%) pre- and post-TM respectively.\textsuperscript{16}

There were also significant reductions in TT and LOS at the LCH between the two groups. In the pre-TM group average TT was 13 hours and in the post-TM group that was reduced by 87% to 1.7 hours. LOS decreased by 97% from 47 to 1.5 hours. This reduction in TT and LOS demonstrates the increased efficiency of the rural trauma system through the use of telemedicine.\textsuperscript{16}

Limitations discussed in this study to the telemedicine process included connection speed of the communication equipment, as well as the training required to use hi-tech video equipment. Despite these limitations the authors concluded that TC hospital costs were significantly reduced without changes in patient mortality. Additionally they stated, “telemedicine significantly improved rural LCH evaluation and management of trauma patients.”\textsuperscript{16}
“Initial Experiences and Outcomes of Telepresence in the Management of Trauma and Emergency Surgical Patients” 2009

Latifi et al performed a 4-year retrospective cohort study of the Southern Arizona Telemedicine and Telepresence (SATT) program’s use for trauma patients. The SATT program was initiated in 2004 and funded through grants to incorporate five rural hospitals and the University Medical Center (UMC) in Tucson, which was the only Level 1 trauma center (TC) in Arizona at the time. Total initial cost of implementation of the SATT program was $275,000, with an additional $7500 per year in fixed costs for training, maintenance, and technical support.

During the study, data was collected on type of consult, mechanism of injury (MOI), change in management, transfer status, impacts on survival, and cost implications. There were no criteria for the use of the telemedicine equipment; it was entirely at the discretion of the rural provider to initiate a consult. Of the 35 trauma consults performed during this study, 27 were transferred to the UMC while 8 remained at the LCH. Of those 27 who were transferred, 8 received surgical care while 19 were treated non-operatively and the average LOS was 5.5 days.

A total of 8 trauma transfers were avoided because of the teleconsults performed. According to the authors, emergency ground transfers can cost up to $2661, while air transfers cost can be as high as $25,494 in the state of Arizona. Therefore the amount saved by treating 8 patients at the LCH with the aid of TM ranged from $21,288 to $203,952 in transport costs alone. Factoring hospital costs at the TC would greatly increase those amounts, but this study did not report total hospital cost data. Despite this the authors stated, “The savings from the prevention of 1 unnecessary air transport was
enough to pay for the entire cost of 1 [telemedicine] system at the referring hospital, not including fixed costs such as internet access, installation, and maintenance.” 17

The authors stated further benefits of the TM consults including potentially saving five lives based on immediate interventions possible through TM, as well as continuing education for rural providers working hands-on under the guidance of a trauma surgeon. Obstacles to the use of TM addressed in this study included training health care providers how to use the equipment, and some staff found the system intimidating to use and avoided it. 17 They attribute this to user interface complexity as well as low volume of teleconsults. Another issue with the SATT program was the difficulty moving the system from room to room if necessary since the program was not using a wireless network to communicate with the TC. Despite these barriers the authors concluded, “the cost savings to the medical system are potentially significant,” and “the quality of trauma patient care has been considerably enhanced.” 17

“The Use of Telemedicine for Real-Time Video Consultation between Trauma Center and Community Hospital in a Rural Setting Improves Early Trauma Care: Preliminary Results” 2001

Rogers et al 18 performed an 8-month cohort study in upstate New York and Vermont. This telemedicine program was initially funded by a grant and incorporated 4 rural community hospitals with a TC at the University of Vermont (UVM) and it’s partner teaching hospital Fletcher Allen Health Care (FAHC). 18 Data collected during this study included patient demographics, injury severity score (ISS), revised trauma score (RTS), and mortality. 18
There were multiple sites at UVM/FAHC for teleconsults including a dedicated telemedicine room, operating rooms, surgeon’s offices, and the emergency department (ED). In addition to these, each of the participating surgeons had a telemedicine unit set up in their homes. The goal was to have an available consult no more than 5 minutes away when the request is placed, and to make the telemedicine process as effortless as possible. The cost of these systems was approximately $10,000 each to set up, with fixed ongoing expenses for network connections and technical support.

During the 8-month period 26 trauma consults were performed. There were specific criteria to initiate a consult which included: Glasgow Coma Scale (GCS) ≤ 13, systolic blood pressure <90, penetrating truncal trauma, respiratory distress (rate <10, or >30), amputation proximal to the ankle or wrist, or at the treating physician’s discretion. Of the 26 consults 19 were transferred to the TC while the remaining 7 were treated at the LCH. Those transferred were more critically injured trauma patients indicated by higher ISS and lower RTS. The transferred group had ISS 23.75 ± 9.6 and RTS score of 4.82 ± 2.6, compared to those not transferred ISS and RTS were 10.5 ± 9.1 and 7.06 ± 1.45 respectively.

Though this study did not address the cost savings of the 7 avoided transfers. They did mention the cost of setup, and how the program resulted in proper triaging of trauma patients allowing those who are not as severely injured to get treatment at the LCH. While those patients in need of the expertise and abilities of a Level 1 TC were transferred for definitive care. The authors brought up other benefits as well, including potentially two life saving interventions that resulted from the teleconsult, and more effective care from the rural provider not having to leave the patient to seek advice. As
well as, better continuity of care once patients arrive at the TC since the surgeon has already seen the patient. Barriers addressed by the authors were licensing and credentialing between practitioners and facilities, as well as malpractice issues. 18

**DISCUSSION**

**Benefits To Telemedicine**

Health care costs can be measured in a myriad of ways, and for each patient there is a multitude of categories that combine to sum up the total hospital cost. In regards to the rural trauma patient, the need to transfer from a LCH to a TC for definitive care is one major factor. What telemedicine can offer is a means to assess a trauma patient with the eyes, ears, and knowledge of a TC specialist to properly assess the disposition of those who need transfer from those how can be managed at the LCH. Previous narratives have already mentioned one benefit of teleconsults is the ability to reduce unnecessary transfers and procedures for rural trauma patients. 7-10,12-14 Each of the studies in this review 16-18 demonstrated this reduction. Duchesne et al 16 went from 100% of trauma patients being transferred to a TC to 11% (89% decrease). While Lafiti et al 17 and Rogers et al 18 both avoided transfers in roughly 23% of patients, though neither study had pre-TM transfer data to compare. Decreasing the number of transfers also lowers the inherent risk of transporting patients via ground or air not only for the patient, but for the healthcare professional performing the transport as well.

Each of these transfers that were avoided were dollars saved. As Latifi et al 17 stated the cost of air transfer in the state of Arizona could be as high as $25 494, and ground transfers were as high as $2661. During that study the 8 avoided transfers reduced expenditures by as much as $203 952. While these figures are highly variable depending
on distance travelled and may not be the same in every state. The cost of fuel and insurance has undoubtedly risen since the study was performed in 2009, and will more than likely continue on that trend into the foreseeable future. But as transport costs have risen, the cost of technology has fallen. Lambrecht et al.\(^9\) wrote an analysis of a telemedicine program in rural North Dakota back in 1995. The program involved three rural LCH and a Level 2 trauma center. The telemedicine equipment cost was approximately $100,000 for each site.\(^9\) Fast forward just 6 years and in 2001 and Rogers et al.\(^18\) reported the cost for telemedicine equipment for the program in upstate New York and Vermont was roughly $10,000 per site.\(^18\) More recently Joseph et al.\(^8\) reported on a program in Arizona using nothing but iPhones\(^{TM}\) for teleconsults. Feedback from providers on both ends of the consults agreed they were effective at improving patient care and could reduce the number of unnecessary procedures and transfers.\(^8\)

There are many other potential benefits to telemedicine, the most important being enhancing on site patient care through the direction of a TC specialist.\(^7,10,12,13,19\) Both Latifi et al.\(^17\) and Rogers et al.\(^18\) stated that there was potentially life saving interventions given on multiple patients as a result of the teleconsult with the TC. Certain interventions were more likely to be utilized under the guidance of the TC. An example of this was patients in one study were more likely to receive transfusions at the LCH at the discretion of a TC through TM.\(^16\) This enhanced care continues at the TC as well. For those patients who are deemed in need of a TC, care may be expedited upon their arrival since the receiving physician has essentially already seen the patient.\(^7\) Moreover, those patients transferred are more likely to receive the proper mode of transport. Patients transferred via telephone consultation were more apt to travel via air, when less costly ground
transport would have been sufficient. Studies also revealed significant reductions in TT and LOS at the LCH. Duchesne et al demonstrated TT was reduced from 13 hours by 87% to 1.7 hours, while LOS at the LCH decreased by 97% from 47 to 1.5 hours. Multiple authors have also noted the potential for continuing education for the healthcare providers at the LCH working hands-on under the guidance of the TC. Practitioners have noted telemedicine allowed them to re-acquire and learn new skills rather than refer patients elsewhere. This allows for increased viability and utilization of LCH. This support also lowers the burden on LCH adding an extra level of confidence knowing there is on-demand advice when needed.

**Barriers To Telemedicine**

However, there are multiple barriers and pitfalls of telemedicine as well. Among the largest of these barriers is maintaining patient confidentiality and HIPPA regulations over network connections. Also the credentialing and licensure of practitioners at multiple facilities has proven difficult. This is usually overseen at the state level, which makes boarder towns increasingly problematic. Federal regulations may be the answer to provide cross boarder telemedicine authorization for medical practitioners. Malpractice is another legal issue facing telemedicine. As previously noted it should be predetermined which facility will cover the consulting physician. Also in the case of liability, when consults weren’t performed when available, or whom liability falls on when a consult is performed are both issues facing practitioners and their employing entities.
Outside the legal aspects of telemedicine are the logistical requirements to communicate between facilities. The proper bandwidth necessary to send video, audio and high resolution images is beyond the scope of this paper, but issues were noted by multiple authors in regards to accessing and maintaining high speed networks for telemedicine consults.\(^5,13,17\) Though it appears that recent attempts to correct this issue are through the use of cellular networks rather than hard lines.\(^8\) Once the equipment is in place healthcare providers must be trained in how to use it. Training proved cumbersome in multiple settings due to complex systems and the infrequency of use.\(^12,17\) This difficulty is contrasted with the fact that some programs showed high ease of use reported by physicians.\(^8,18\) Therefore, this hurdle varies on the system implemented and the turnover of staff members using the equipment.

**Study Limitations**

The studies in this systematic review are not without their flaws as well. Duchesne et al\(^16\) had the most complete view of the difference in transfers between pre- and post-TM patients. However, the author’s retrospective analysis only described what data they collected on the trauma patients and failed to clearly describe what qualified a patient to be considered a trauma patient. The fact the transfer rate was 100% in the pre-TM group makes it likely their data collection involved only transferred patients and not all patients arriving at LCH for traumatic injury. Next, Duchesne et al did not report a complete cost analysis. The authors calculated total hospital costs for the TC only and didn’t include the additional costs to the LCH. Moreover, they failed to evaluate
transport costs. Lastly, they did not report the cost incurred to set up the telemedicine system in upstate New York and Vermont.

Latifi et al\textsuperscript{17} and Rogers et al\textsuperscript{18} had small sample sizes. Latifi et al\textsuperscript{17} ran a 4-year study, which totaled only 35 teleconsults for trauma. Rogers et al\textsuperscript{18} study of teleconsults merely collected data for 8 months and totaled 26 trauma patients that took part in telemedicine. For the purpose of this review, neither study reported a number of transferred patients before the use of telemedicine for comparison. Although they both described the cost of implementing a telemedicine system, Rogers et al did not report any cost savings analysis.

**Recommendations for further study**

Future studies should include an analysis of all patients presenting to LCH for trauma injuries and what percent are treated versus transferred without the aid of TM. Research should contrast how many patients are treated definitively at the LCH or transferred to a TC with the aid of TM consults. This will allow an objective view as to the impact of TM on the ability for LCH to apply comprehensive assessment techniques, perform appropriate interventions, and properly evaluate the disposition the patient under the guidance of a TC. Studies should also analyze the cost of implementing a TM program, and compare this to the expense rate of emergency air and ground transports. By tracking expenditures, a true comparison can be performed to determine return on investment of telemedicine implementation. Furthermore, studies may need to address whether baseline criteria should be met before teleconsults are performed, as two studies in this review took differing approaches.\textsuperscript{17,18} Future endeavors in telemedicine may also
aim to bring broader regulations to the credentialing and licensure of medical professionals involved in telemedicine. Streamlining this process and expanding it across regions and states may allow wider use of telemedicine in rural areas.

**CONCLUSION**

To address the question whether telemedicine is a cost effective alternative to transporting patients from a LCH to a TC for definitive care, information had to be extrapolated from all three studies. All three studies showed the possibility for telemedicine to allow expert TC consultants to reach rural trauma patients. Teleconsults demonstrated that TC input offers proper disposition and differentiation of those patients who can be managed by a LCH, and those who truly require the resources of a TC. Each study proved specialist involvement through TM has the ability of reducing the number of TC transfers. Additionally, the guidance of experienced trauma specialist may enhance the ability of the LCH and provide a higher quality of care with maximum use of available resources. The studies also addressed the cost of telemedicine implementation as well as cost of emergency transport. Comparing these numbers between studies shows there may truly be a financial benefit to the health care system through the use of telemedicine. Regardless of the monetary outlook, telemedicine brings the ability to place a trauma specialist in the emergency room of a rural hospital on-demand, allowing definitive trauma care to begin immediately upon the patient’s arrival enhancing that quality of care.
References


Table I. Characteristics and Summary of Reviewed Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Location</th>
<th>Length of study</th>
<th># of teleconsults</th>
<th># of trauma transfers without TM</th>
<th># of trauma transfers w/ TM</th>
<th># of transfers avoided</th>
<th>Est. cost savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duchesne J. et al</td>
<td>Mississippi</td>
<td>5 year</td>
<td>463</td>
<td>351</td>
<td>51</td>
<td>412</td>
<td>Total*: $6,505,941</td>
</tr>
<tr>
<td>Latifi R. et al</td>
<td>Arizona</td>
<td>4 year</td>
<td>35</td>
<td></td>
<td>27</td>
<td>8</td>
<td>Air: $203,952**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ground: $21,288**</td>
</tr>
<tr>
<td>Rogers B. et al</td>
<td>New York, Vermont</td>
<td>8 month</td>
<td>26</td>
<td></td>
<td>13</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

* Total estimated savings of hospital costs for patients transferred to a trauma center.
** Calculated using estimated cost of air/ground transport multiplied by the # of avoided transfers.

Figures

![Figure I: Pre-TM Patient Outcomes (n=351)](image1.png)

![Figure II: Post-TM Patient Outcomes (n=263)](image2.png)