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Using tele-emergency to avoid patient transfers in rural emergency departments: An assessment of costs and benefits

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Abstract

Introduction: Tele-emergency can address several challenges facing emergency departments in rural areas. The purpose of this paper is to (a) examine the rates of avoided transfers in rural emergency departments that adopted tele-emergency applications; and (b) estimate the costs and benefits of using tele-emergency to avoid transfers.

Methods: Analysis is based on 9048 tele-emergency encounters generated by the Avera eEmergency programme (Sioux Falls, South Dakota) in 85 rural hospitals across seven states between October 2009–February 2014. For each non-transfer patient, physicians indicated whether the transfer was avoided because of tele-emergency activation. The cost-benefit analysis is conducted from the hospital, patient and societal perspectives, and includes technology costs, local hospital revenues and patient-associated savings. All monetary values are expressed in US$. Sensitivity analysis is conducted by examining the worst and best case scenarios of costs, revenues and savings.

Results: In these analyses, 1175 avoided transfers were attributed to tele-emergency. From a rural hospital perspective, tele-emergency costs around US$1739 to avoid a single transfer. However, tele-emergency saves around US$5563 in avoided transportation and indirect patient costs. Combining these, from a societal perspective, tele-emergency has the potential to result in a net savings of US$3823 per avoided transfer while accounting for tele-emergency technology costs, hospital revenues, and patient-associated savings.

Conclusion: This study highlights various stakeholder perspectives on the financial impact of tele-emergency in avoiding patient transfers in rural emergency departments. Telemedicine has the potential to reduce the number of transfers of emergency department patients and generate some revenue for rural hospitals despite associated technology costs, while incurring substantial patient savings.

Keywords

Telemedicine, telehealth, tele-emergency, emergency department, avoided transfers, cost-effectiveness analysis

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Introduction

Emergency departments (EDs) in the USA face ongoing challenges related to growing demand for services, declining financial support, and increased case complexity. Small and rural hospitals, in particular, suffer from financial distress and shortages of emergency medicine and other specialty physicians.[1] Furthermore, the sporadic and unexpected nature of emergency patients makes it difficult to plan, staff, and equip rural EDs to provide services at the same intensity and quality seen at their higher-volume urban counterparts.[2] Telemedicine has the potential to address several of these challenges. It can provide clinical support for ED clinicians to improve health outcomes while overcoming geographic barriers and resource constraints in rural areas. Tele-emergency (tele-ED) improves access to emergency medicine specialists and other consultants, which allows for timely diagnoses and treatment regimens that translate to better patient outcomes.[3,4] The increased interest in tele-ED is driven, in part, by technological advances that have made equipment less expensive and more effective.[5]

While the evidence on tele-ED effectiveness and feasibility in meeting the needs of small and rural hospitals is

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well documented in the literature and the potential for financial gain has been estimated,[6–8] studies of economic evaluations are limited.[3,9–11] Systematic reviews of cost effectiveness studies of telemedicine interventions, not limited to emergency department or trauma care, show an increased use of economic tools for evaluation of telemedicine overtime. While Mistry's review concluded that there is 'no conclusive evidence that telemedicine interventions are cost-effective compared to conventional health care',[10] De la Torre-Díez and colleagues concluded that 'some cost-effectiveness studies demonstrate that telemedicine can reduce the costs, but not all' (p. 81).[11] The mixed results reported in the literature reflect the variation in medical specialty (e.g. tele-cardiology, tele-emergency), technology (e.g. real-time audiovisual, Internet-based application), setting (e.g. rural, urban) and study methodology. Thus, given the scarcity of data and limitations of empirical evaluations, the reviews called for more robust assessments.[9–11]

Tele-ED may be an effective intervention to reduce the number of emergency transfers of patients from remote rural hospitals to more advanced tertiary hospitals or trauma centres.[8] Three separate studies on the impact of telemedicine on trauma care investigated the impact on transfer rates, specifically.[12–14] The results indicated a reduction in the number of transfers of between 23–89% of patients. However, in all three papers the assessment of the role of telemedicine in avoiding transfer was considered as a secondary outcome and was limited to trauma or surgery patients. Further, the study population was limited, ranging from four rural hospitals with 26 telemedicine consultations over an eight-month period to seven community hospitals with 463 telemedicine patients over a 30-month period.

Only two studies have attempted to estimate the cost of using telemedicine to avoid patient transfer as their primary aim. The first one demonstrated that paediatric tele-cardiology was effective in reducing the number of patient journeys by 42%, with an incremental cost-effectiveness ratio of US$2609 per patient journey avoided.[15] The second study assessed avoided transfers in ED patients but was limited to two hospitals and provided estimates of total hospital revenues and community income attributable to avoided transfers without reference to costs of telemedicine implementation. The revenues were estimated between US$42,055 and US$199,939 for an estimated avoided transfer of 5−22 patients.[6] As secondary outcomes, Latifi and colleagues estimated that tele-trauma can save an average of US$19,698 per avoided air transport and US$2055 per avoided ground transport.[13] Lastly, the Center for Information Technology Leadership (CITL) projected the impact of telemedicine in terms of the reduction of patient transfers. Based on national projections, they concluded that telemedicine could avoid 646,000 transports and save US$408 million annually.[16]

This paper expands on the literature on the cost effectiveness of telemedicine and its impact on transfer rates by using over 9000 telemedicine encounters from 85 rural hospitals as part of a large regional telemedicine network across seven states over a 52-month period. The objectives of this paper are to: (a) examine the rates of avoided transfers in rural EDs that adopted tele-ED applications; and (b) provide a model for estimating the costs and benefits of using tele-ED to avoid transfers.

Methods

Study population and site

Encounter data for the current analysis were generated from the Avera Health eEmergency programme. Through grant funding by US Health Resources and Services Administration (HRSA) and the Leona M. and Harry B. Helmsley Charitable Trust, Avera Health was tasked to develop a programme that involved virtual emergency care provided through a central hub to support care in rural hospitals. The federal and private funds helped offset start-up and equipment costs to support the implementation and growth of the eEmergency programme. The ongoing operating costs of Avera eEmergency are covered by monthly services fees paid by facilities receiving services. Initiated in October 2009, Avera eEmergency is now the largest regional tele-ED network in the USA, with a hub staffed 24/7 by emergency medicine physicians and registered nurses from Avera McKennan Hospital – a private non-profit tertiary care hospital located in Sioux Falls, South Dakota. This hub uses interactive audio-visual technology to provide tele-ED services to more than 100 rural hospitals across the country (as of June 2016).[17] It is estimated that the eEmergency programme provides over two million rural residents with local access to the resources of a Level II Trauma Center. The hub creates records in a tele-ED log every time the eEmergency system is activated to track information related to the encounter including technical issues, clinical assessment, and patient disposition. The tele-ED log data were linked to participating rural hospitals electronic medical records (EMRs) that included 173,339 ED visits between October 2009–February 2014 in 85 rural hospitals, 80 of which have a critical access hospital (CAH) designation, in seven states: South Dakota, North Dakota, Minnesota, Iowa, Nebraska, Wyoming and Montana. This analysis is based on 9048 encounters in which tele-ED was activated. Further details on study population and site are described elsewhere.[18]

Decision model

Once the patient arrives at the rural ED, local clinicians assess their medical condition to determine whether a tele-ED consultation is desired. If so, the tele-ED service is activated. A previous analysis of clinical situations in which tele-ED was activated in a sub-sample population showed that patients with cardiac disease, injury, mental

illness, ill-defined symptoms and patients who were candidates for transfer were more likely to experience a tele-ED consultation.[18]

For each tele-ED patient that was not transferred, a hub emergency medicine speciality physician in consultation with the referring (local) ED staff member, indicated on the tele-ED log whether a transfer was avoided because of tele-ED activation. The physicians responded to the following statement: 'In your opinion, did the involvement of [tele-ED] in this case help to prevent the patient from transferring?' with four options 'Yes', 'Maybe', 'No', 'Not Applicable'. 'Yes' reflected cases where it was initially believed that the patient required transfer for advanced care but was instead retained in the local hospital due to the tele-ED consult. The hub physicians used the following criteria to determine that a transfer was avoided ('Yes'): (a) local staff call-in on video and state they want to transfer the patient, have arranged a transfer, are considering transfer or are wondering if they should transfer; (b) the hub team has a meaningful interaction with the site, that includes the ED physician or another consultant; and (c) the patient does not transfer. If there were any doubts regarding the role of tele-ED in avoiding transfer, the case was classified as 'Maybe'. Cases of 'No' and 'Not Applicable' reflected instances in which the patient was retained in the local hospital due to factors unrelated to tele-ED or patients who did not require a transfer initially but the local clinicians activated tele-ED to receive consultation from the hub physicians (i.e. local staff and family were never planning to transfer the patient).

Cost and benefit analysis approach

The cost-benefit analysis was conducted from the hospital perspective and societal perspective. The hospital perspective reflects the technology costs incurred by the local hospital and the local hospital revenues associated with avoided transfers due to tele-ED implementation. This cost component included costs of the tele-ED technology and services borne by the local hospital including tele-ED start-up costs, ongoing connectivity and operating costs, and annual service fees. All costs and benefits were based on estimates provided by the Avera eEmergency programme or standard costs/savings of implementing similar technology reported in the literature.[19]

The societal perspective included, in addition to the hospital-level costs and revenues, the savings associated with avoided transfers at the patient-level and is considered the classical approach for making optimal societal decisions based on economic evaluations.[20,21] A primary goal of including societal-level estimates is to move beyond the details of who is paying whom. Rather, we attempt to answer whether the tele-ED intervention can reduce the burden of healthcare costs via a decrease in total resources used to provide care. All monetary values are expressed in US dollars (US$).

Sensitivity analysis

Sensitivity analysis was conducted by examining the most and least conservative estimates of the value of tele-ED activation and its effect on avoided transfer. The worst-case scenario included the highest estimates of tele-ED costs (start-up and ongoing costs) reported in the literature as well as the lowest estimates of benefits of tele-ED activation (least revenues and minimal number of avoided transfers attributable to tele-ED activation). The best-case scenario included the lowest approximates of costs and highest attributable revenues and savings.

Key assumptions

For the purposes of this evaluation, it was assumed that there were no significant differences in the quality or outcomes of care provided during a tele-ED-supported encounter and the in-person care provided at the remote hospital. The evidence to support such an assumption from randomised control trials on tele-ED implementation, especially those assessing patient outcomes, is limited.[3] Nonetheless, the observed outcomes reported in the tele-ED literature are generally positive, particularly in relation to clinical effectiveness such as safety and patient improved health.[3]

Results

The tele-ED log provided data on 9048 encounters. Table 1 displays the descriptive statistics of the hospitals included in the study. Hospital size ranged from 10–133 beds, with most (94.1%) having 25 beds or less. Tele-ED had been in place an average of 30 months (range: 1–52 months) with an average of 106.45 tele-ED encounters

Table 1. Descriptive statistics ($n = 85$ hospitals).

	Count (*n*)	%
Hospital status		
Critical access hospital (CAH)	80	94.12
Prospective payment system (PPS)	5	5.88
Hospital size		
0–20 beds	27	31.76
21–25 beds	53	62.35
26+ beds	5	5.88
Tele-ED implementation longevity		
1–23 months	28	32.94
24–47 months	45	52.94
48–52 months	12	14.12
	Mean	SD
Tele-ED encounters	106.45	95.95
Tele-ED frequency of use (activation per month)	4.00	3.86

Tele-ED: tele-emergency; SD: standard deviation.

(range: 1–480 encounters) per hospital, for an average rate of 4.0 tele-ED encounters per month (range: 0.1–20.9 encounters/month).

Table 2 displays disposition status for ED patients when tele-ED was activated in contrast to when tele-ED was not activated. In cases where tele-ED was not activated, the majority (88.2%) of the encounters were discharged while less than 1% were transferred to another hospital. When tele-ED was activated, less than a quarter of the tele-ED encounters were discharged (23.4%) while in nearly half (47.6%) of tele-ED encounters the patient was transferred to another hospital. Difference in discharge and transfer rates are expected since a large portion of the ED visits are considered relatively low acuity cases (e.g. earaches, sore throats and UTIs) for which tele-ED was never a consideration. Furthermore, tele-ED was activated in most cases in which the initial assessment of the patient indicated a possible need for transfer to coordinate and facilitate the transfer process.[18]

Table 2 further shows that tele-ED was determined to have prevented patient transfer in 683 (15.8%) activations and to have 'maybe' prevented transfer in an additional 984 (22.8%) activations. These patients formed the foundation for the following financial implications of the use of tele-ED to avoid transfers. For all subsequent base-case cost estimates, the number of tele-ED avoided transfers was assumed to be 1175 (i.e. all definite avoided transfers (683)+½ the potentially avoided transfers (½*984 = 492)); the worst-case scenario estimate included only the definite 683 avoided transfers; and, the best-case scenario estimate included all 1667 (=683 + 984) definite and potentially avoidable transfers.

The issue of patient disposition from the ED is important to tele-ED cost-effectiveness. We can envision three scenarios in which patient death was proximate to the tele-ED consult: (a) the patient died in the remote ED prior to tele-ED activation – these patients would not be included in our analyses since tele-ED was not activated; (b) the patient died in the remote ED after tele-ED activation. We presume that tele-ED would have recommended no transport (due to terminal condition), and thus tele-ED saved transport costs, but personal and other opportunity cost savings would not be applicable. Therefore, we do not include the latter costs in our calculations; (c) the patient died during the transfer (after tele-ED activation). In this scenario, there would be no savings from tele-ED activation since transfer was not avoided.

Local hospital perspective

Revenues. Tele-ED activation generates hospital revenue by increasing local ED service provision, and increasing inpatient admissions when transfers to other hospitals are avoided. Local hospital revenue from additional ED services provided and billed because of tele-ED activation is estimated at US$60 (range: US$40–80).[19] The 9048 tele-ED encounters in the 85 hospitals provided a total of US$542,880 (range: US$361,920–732,840) in additional revenues over the course of tele-ED implementation. To determine the revenues attributable to local admissions among avoided transfers, the average contribution margin per admission was assumed to be US$1452.[19] Among the 1175 avoided transfers (range: 683–1667), 621 cases (range: 354–887) were admitted to the local hospital. Therefore, the total local hospital admission revenues were estimated at US$901,692 (range: US$514,008–1,287,924).

Expenses. Avera eEmergency recommended a minimum set of equipment to be purchased by local hospitals including a videoconferencing codec, monitor, network router, microphone and wall-mount brackets. The required audio-visual equipment and initial connectivity costs between the hub and spoke were reported to cost around US$30,000 (range: US$17,000–50,000) per hospital.[19,22,23] Ongoing connectivity and operating costs were estimated to average US$500 per month (range: US$300–700); over the 52-month study period

Table 2. Discharge disposition of the emergency department (ED) encounters.

Disposition status	Tele-ED not activated		Tele-ED activated total		Tele-ED patient transfers prevented among those not transferred									
					Yes		Maybe		No		Not applicable		Not specified	
	n	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Admitted to local hosp.	6634	(4.2%)	2078	(23.4%)	354	(51.8%)	533	(54.2%)	655	(36.1%)	373	(44.7%)	163	(49.1%)
Discharged	138,758	(88.2%)	2075	(23.4%)	288	(42.2%)	425	(43.2%)	880	(48.5%)	344	(41.3%)	138	(41.6%)
Pronounced dead	791	(0.5%)	358	(4.0%)	30	(4.4%)	11	(1.1%)	218	(12.0%)	68	(8.2%)	31	(9.3%)
Transferred	1059	(0.7%)	4224	(47.6%)	–	–	–	–	–	–	–	–	–	–
Other	10,019	(6.4%)	138	(1.6%)	11	(1.6%)	15	(1.5%)	63	(3.5%)	49	(5.9%)	0	(0.0%)
Not specified	7030		175		–	–	–	–	–	–	–	–	–	–
Total	164,291		9048		683		984		1816		834		332	

Tele-ED: tele-emergency.

this translates to US$26,000 (range: US$15,600–36,400) per hospital. In addition to the ongoing connectivity costs, Avera charges each hospital an average of US$60,000 (range: US$0–90,000) per year to provide eEmergency services.[19]

The service fee covers Avera's expenses (e.g. hub personnel salaries, equipment and connectivity costs). The sensitivity analysis includes the reduction of service fees to zero to account for telemedicine hub systems that are funded by third-party payers to provide this service under special grants. One example is the Evidence-Based Tele-Emergency Network Grant Program (EB TNGP) by the HRSA Federal Office of Rural Health Policy (FORHP).[24] This programme supports the implementation of systems to deliver ED consultation services via telemedicine to rural providers.

Since the focus of the analysis is limited to avoided transfers and we do not include other benefits associated with tele-ED implementation (e.g. staffing levels and education savings), only a fraction of the technology costs should be attributed to the cost analyses of using tele-ED to avoid transfers. To that end, the cost estimates were multiplied by a constant fraction of 13% (=1175 avoided transfers/9048 tele-ED encounters) that is reflective of the avoided transfer rate.

Societal perspective

Savings associated with avoided patient transfers included: (a) transportation costs; (b) personal expenses; and (c) indirect costs including lost productivity.

Transportation savings. To estimate patient transportation savings, actual transfers were used to develop multipliers for each origin-destination city pair by the mode of transportation. In other words, the mix of actual transfer destinations and modes for each origin hospital was used to estimate how and where avoided transfers would have occurred. Of all patients transferred, just over half (51%) were transferred to Sioux Falls, South Dakota. Ground ambulance was the most common (45%) mode of transportation (Table 3). These rates were then applied to the number of avoided transfers from each origin city to provide an estimate of the numbers of each method of transfer to each destination. Those counts were applied to travel distances. Travel cost estimates are conservatively based on the Centers for Medicare and Medicaid Services (CMS) Ambulance Fee Schedule for 2012.[25]

Table 3 summarises the estimates of prevented transfers, total miles and costs saved for each method of transfer. The total estimated savings for avoided patient transportation was US$4,509,848 (range: US$2,626,324–6,393,371). For accompanying person transportation costs, driving mileage was applied to all origin-destination city pairs and was doubled to account for the round-trip travel.

Personal expenses savings. Lodging and personal expenses for an accompanying person were estimated at US$129 per person per day.[26] For 1140 avoided transfers (excluding 35 cases that were pronounced dead) and an average length of stay of five days,[27,28] the total cost savings for personal expenses were estimated at US$734,978 (range: US$421,185–1,048,770).

Opportunity cost savings. Lost productivity was estimated at US$128 per day for full-time wage earners associated with missed workdays and US$85 per lost day for an adult who is not working.[29] Determination of work-status was based on age group: 0–17 years-old patients (15%) were assumed to have US$0 lost productivity per day; 18–64 years-old patients (50%) were assumed to have US$128 lost productivity per day; and 65+ years-old patients (35%) were assumed to have US$85 lost productivity per day. In addition, the accompanying family member was assumed to be the parent/guardian for persons under 18 years or the spouse for those older than 18 years; and we assumed a working rate of 50% for those members. The lost productivity cost savings sum up to US$1,136,530 for five days (range: US$651,363–1,621,165).

Table 4 shows the breakdown of the costs and benefits of using tele-ED technology to avoid patient transfer in 85 rural hospitals over the period of 52 months from both the hospital and the societal perspectives. Considering the expenses and revenues associated with using tele-ED to avoid patient transfer simply from a local hospital perspective, the results indicate that each

Table 3. Estimated patient transportation cost savings associated with avoided patient transfers.

		Base-case (1175 avoided transfers)			Worst-case scenario (683 avoided transfers)			Best-case scenario (1667 avoided transfers)		
Transfer method	%	Transfers	Mileage	Costs (US$)	Transfers	Mileage	Costs (US$)	Transfers	Mileage	Costs (US$)
Ground ambulance	45%	529	59,585	673,710	307	33,735	381,842	750	85,434	965,577
Rotary wing	35%	411	32,720	2,696,961	239	19,058	1,567,611	583	46,381	3,826,311
Fixed wing	15%	176	23,784	1,136,136	102	14,279	675,008	250	33,289	1,597,264
Private automobile	5%	59	5288	3041	34	3240	1863	83	7337	4219
Total	100%	1175	121,377	4,509,848	683	70,312	2,626,324	1667	172,441	6,393,371

Table 4. Breakdown of costs and benefits of using tele-emergency (tele-ED) technology to avoid transfers in 85 rural hospitals over 52-month period (October 2009-February 2014), in US$.

	Base case	Worst case	Best case
Local hospital-level cost/benefit			
Revenue			
Tele-ED encounter revenue	542,880	361,920	723,840
Local hospital admission revenue	901,692	514,008	1,287,924
	1,444,572	875,928	2,011,764
Expenses			
Tele-ED start-up expenses	331,151	551,918	187,652
Connectivity and operating expenses	286,997	401,796	172,198
Tele-ED service fee	2,869,971	4,304,957	0
	3,488,119	5,258,670	359,850
Direct margin	*(2,043,547)*	*(4,382,742)*	*1,651,914*
Direct margin per avoided transfer	*(1,739.19)*	*(6,416.90)*	*990.95*
Direct margin per CAH per year	*(5548)*	*(11,899)*	*4485*
Patient-level cost/benefit			
Savings[a]			
Avoided private automobile expenses	3041	1863	4219
Avoided ground ambulance expenses	673,710	381,842	965,577
Avoided rotary wing expenses	2,696,961	1,567,611	3,826,311
Avoided fixed wing expenses	1,136,136	675,008	1,597,264
Avoided lost patient productivity	529,480	303,640	755,320
Avoided family transportation expenses	154,663	89,827	219,498
Avoided family lodging/personal expenses	734,978	421,185	1,048,770
Avoided lost family productivity	607,050	347,723	865,845
Savings margin	*6,536,018*	*3,788,699*	*9,282,804*
Savings margin per avoided transfer	*5,562.57*	*5,547.14*	*$ 5,568.57*
Societal cost/benefit			
Revenue	7,980,590	4,664,627	11,294,568
Expenses	3,488,119	5,258,670	359,850
Societal margin	*4,492,471*	*(594,044)*	*10,934,718*
Societal margin per avoided transfer	*3823.38*	*(869.76)*	*6559.52*

CAH: critical access hospital.
[a]Assumes no additional patient expenses associated with avoided transfers.

avoided transfer costs the local hospital around US$1739. However, each avoided transfer results in savings of around US$5563 per patient in transportation expenses and indirect costs. To this end, from a societal perspective, the combined results indicate that tele-ED technology has the potential to generate an average savings of US$3823 per avoided transfer.

Sensitivity analysis

The sensitivity analysis assessed the variability in cost estimates reported in the literature and the variability in number of avoided transfers in terms of benefits. The worst-case scenario reflects the highest estimates of start-up costs per hospital (US$50,000), operating costs (US$700/month), and service fee (US$90,000/year) along with the lowest estimates of benefits in terms of least revenues (US$40 per encounter), minimal number of local admissions due to avoided transfers (354 admissions); and minimal number of avoided transfers attributable to tele-ED activation (683 avoided transfers) for calculations of avoided patient expenses (Table 5). The findings indicate that if the worst-case scenario of costs and savings was assumed, tele-ED activation could cost the society US$870 to avoid a single transfer.

On the contrary, the best-case scenario reflects the lowest estimates of start-up costs per hospital (US$17,000), operating costs (US$300/month), and service fee (US$0/year) along with the highest estimates of benefits in terms of most revenues (US$80 per encounter), maximal number of local admissions due to avoided transfers (887 admissions); and maximal number of avoided transfers attributable to tele-ED activation (1667 avoided transfers) for calculations of avoided patient expenses.

Table 5. Itemised breakdown of cost and benefit parameters showing values included in the computation of the three (base, worse and best) case estimates.

	Base case	Worst case	Best case
Local hospital-level revenues			
Tele-ED encounter revenue	US$60 per tele-ED encounter	US$40 per tele-ED encounter	US$80 per tele-ED encounter
Number of tele-ED encounters	9048	9048	9048
Local hospital admission revenue	US$1452 per tele-ED associated admission	US$1452 per tele-ED associated admission	US$1452 per tele-ED associated admission
Number of tele-ED associated admissions	621	354	887
Local hospital-level expenses			
Tele-ED start-up technology expenses	US$30,000 per hospital	US$50,000 per hospital	US$17,000 per hospital
Connectivity and operating expenses	US$500 per hospital per month	US$700 per hospital per month	US$300 per hospital per month
Tele-ED service fee	US$60,000 per year	US$90,000 per year	US$0 per year
Patient-level savings			
Transportation rate schedule	Ground base: US$419.72; Ground/mi: US$7.10; RW base: US$4365.75; RW/mi: US$33.05; FW base: US$5075.84; FW/mi: US$12.38		
Transportation mileage	See Table 3 for details		
Lost patient productivity	US$128 per full-time wage-earner per day	US$128 per full-time wage-earner per day	US$128 per full-time wage-earner per day
	US$85 per non-working individual per day	US$85 per non-working individual per day	US$85 per non-working individual per day
	US$0 per minor per day	US$0 per minor per day	US$0 per minor per day
Full-time wage earners (18–64 years)	567	331	803
Non-working individuals (65+ years)	392	216	568
Minors (0–17 years old)	177	103	251
Lost days	5	5	5
Family transportation expenses	US$0.575 per mile	US$0.575 per mile	US$0.575 per mile
Ground mileage for family member –round trip	268,977 miles	156,220 miles	381,734 miles
Family lodging/personal expenses	US$83 lodging + US$46 allowance per day	US$83 lodging + US$46 allowance per day	US$83 lodging + US$46 allowance per day
Accompanying family members	1139	653	1626
Lost family productivity	US$128 per full-time wage-earner per day; US$85 per non-working individual per day	US$128 per full-time wage-earner per day; US$85 per non-working individual per day	US$128 per full-time wage-earner per day; US$85 per non-working individual per day
Full-time wage earner family members	570	327	813
Non-working family members	570	327	813
Lost days	5	5	5

Tele-ED: tele-emergency; FW/mi: Fixed wing, per mileage; RW/mi: Rotary wing, per mileage.

If the best-case scenario was assumed, tele-ED activation could result in net savings of US$6559 per avoided transfer. The indicated ranges reflect estimate extremes reported in the literature to allow a more comprehensive view and keep predictions of gains/costs in tandem with local variations.

Discussion

Our findings show that tele-ED has the potential to reduce patient transfers from EDs in rural areas, and thus produce savings associated with avoided direct and indirect patient expenses. Based on 9048 tele-ED encounters,

at least 683 patients stayed in the local community thanks to telemedicine. Financially, tele-ED costs the local hospital an average of US$2968 to avoid a transfer, and results in an increased revenue of US$1229 for a net loss of US$1739. However, the importance of the analysis presented in this paper is its attempt to highlight the indirect benefits associated with tele-ED particularly in relation to savings associated with avoided patient transportation expenses, avoided personal expenses, and avoided lost productivity expenses which sum up to US$5563 per avoided transfer. When coupled with the hospital costs and revenues, this number translate to a net saving associated with tele-ED estimated at around US$3823 per avoided transfer from the societal perspective.

The financial benefits reported in this paper reflect the value of direct revenues generated to the hospital in tandem with avoided transfers, avoided patient transportations and indirect patient savings. While it is true that a rural hospital might incur a net loss if they only implement telemedicine to avoid transfers – because the bulk of the savings is generated at the societal level – it is worth noting that telemedicine implementation can be associated with several other direct and indirect benefits beyond the value of avoiding patient transfers. For instance, MacKinney and colleagues present a business case for tele-ED which demonstrates that tele-ED can generate a US$49,841 profit if the rural ED adjusts their processes to take advantage of increased revenues and savings opportunities afforded by the technology.[19] The bulk of financial savings in the business case model came from enhancements in staffing models such as professional recruitment savings and ED physician backup call savings.[19] In our early analysis iterations, we considered including a fraction of the staffing model enhancements associated with tele-ED in our estimates. Although that would result in a positive financial outlook for tele-ED's role in avoiding patient transfer (from the hospital perspective), we thought such savings are not directly related to our objective which was to 'estimate the costs and benefits of using tele-ED to avoid transfers'. To this end, we opted to exclude those direct benefits from our analyses.

In addition to the direct and measurable financial benefits observed, tele-ED also has several non-monetary community benefits, particularly in rural areas.[30] For one, tele-ED contributes to enhanced patient satisfaction by keeping patients closer to their families and support network. The burden of transfer in rural areas is not limited to time and lost productivity. For patients, the ability to be near support groups (relatives and friends) is often critical to high-quality care, and many support group members prefer patients to remain local to facilitate visitation. In particular, older patients rely on such groups for tangible assistance as well as social support. More importantly, the availability of telemedicine services for urgent care means higher chances of patients receiving earlier diagnosis and intervention, even when transfers are necessary. A survey of rural hospitals' perception of telemedicine benefits pointed to its value in enhancing the reputation of hospitals in the community.[30] For hospital administrators and clinicians, telemedicine has a considerable impact on the community perception of hospitals implementing telemedicine and is sometimes sufficient to affect patients' decision about whether to use the hospital. This benefit would, in turn, contribute to the financial outlook of the hospital and the health care providers. Overall, these patient and hospital level benefits that cannot be directly measured in this study could make tele-ED worthwhile even if there is a net cost like the worst-case scenario.

Notwithstanding this paper's innovation that calculates a US$ value associated with avoided patient transfers, a few limitations merit consideration. The estimates presented in this study reflect the success of a single telehealth system that might restrict generalisability. Moreover, the assessment of whether a transfer was avoided because of tele-ED activation was determined in part by a hub physician, who may have had an inherent bias towards the potential of telemedicine in avoiding transfers. However, our quantitative findings are in concurrence with qualitative evidence we received from clinicians and administrators that tele-emergency reduced the need to transfer patients,[4,30] and this reinforces our confidence in the findings. Another limitation is the variability in cost and savings estimates as well as the inability to account for a number of other variables. However, the wide range of estimates that were included in the sensitivity analysis are believed to reflect the variations in telemedicine costs and savings reported in the literature. An important limitation, as well, is the restricted ability to evaluate effectiveness or clinical outcomes of avoided transfers. Finally, the non-randomised nature of tele-ED activation should be carefully considered. Despite the limitation, we argue that the non-randomised activation reflects the actual clinical efficacy of tele-ED in respect to when clinicians decide to activate and benefit from the telemedicine technology.

This study highlights important financial elements of telemedicine implementation in rural hospital EDs. Telemedicine has the potential to reduce the number of transfers of ED patients, resulting in patient savings and satisfaction, while generating incremental rural hospital revenues.

Declaration of Conflicting Interests

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Amanda Bell is the eCARE Quality & Innovation Officer at Avera Health, the developer and operator of the eEmergency programme.

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