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Impact of Telemedicine Monitoring of Community Intensive Care Units on Inter-Hospital Transfers

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Abstract

Background—Tele-ICU programs are increasingly utilized to fill resource gaps in caring for critically ill patients. How such programs impact population and bed management within a healthcare system are not known. Mayo Clinic serves as quaternary referral care center for hospitals in the region within the Mayo Clinic Health System (MCHS). In August of 2013, we implemented tele-ICU monitoring at six MCHS hospital intensive care units.

Objectives—To study the effects tele-ICU monitoring on inter-hospital transfers from community-based ICU's to the quaternary care hospital at Mayo Clinic, Rochester, MN.

Methods—This is a retrospective review of data on inter-hospital transfers comparing trends prior to tele-ICU implementation to those following implementation.

Results—Inter-hospital transfers significantly increased post institution of tele-ICU ($p=0.040$) and was attributed primarily to transfer from less specialized ICUs, ($p=0.037$) as compared to more resource intensive ICU's ($p=0.88$). However, for such patient transfers, there were no significant differences in before and after severity of illness scores, ICU mortality, or in-hospital mortality.

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Conclusion—In a regional health care system, implementation of a tele-ICU program is associated with an increase in inter-hospital transfers from less resourced ICU's to the referral center, a trend that is not readily explained by increased severity of illness.

Keywords

Telemedicine; electronic ICU; inter-hospital transfers

INTRODUCTION

In the United States, approximately 5% of all patients admitted to an intensive care unit (ICU) are transferred to higher centers of care^{1,2}. Inter-hospital transfers generally occur because of a mismatch between perceived patient needs and the referring hospital's resources and/or capabilities. Within a health system, an efficient transfer process is vital for patient care and helps support both the referring hospitals as well as the quaternary care receiving center.

Inefficient triage and transfer systems can lead to delays in health care delivery^{3, 4}. The Society of Critical Care Medicine (SCCM) has established guidelines for safety of patients during transfers, but much delay and deliberation goes into identifying transfer eligible patients, destination hospitals, and transfer negotiations⁵. A qualitative study conducted by Bosk et.al at 3 community hospitals identified 4 phases to a successful transfer: (a) Identifying transfer-eligible patients; (b) Identifying a destination hospital; (c) Negotiating the transfer; and (d) Accomplishing the transfer⁶.

Telemedicine monitoring of ICU's (Tele-ICU) is an increasingly utilized model of caring for critically ill patients⁷. Patients located in a remote ICU are monitored and cared for in a real-time partnership between providers at the remote hospital and intensive care specialists located at a centralized monitoring center.⁸ Some tele-ICU's also function as a logistic center, managing patient flow within a hospital or health system⁹. Since its emergence, multiple studies have attempted to outline the effect of this intervention on patient survival, best practices and cost effectiveness, with variable outcomes.^{9–15}

One expected and well-publicized potential benefit of a tele-ICU program is to enable community hospitals to care for patients locally who might otherwise be transferred to a teaching or destination hospital¹⁶. To further explore this concept and identify trends in ICU population management across a regional health system associated with implementation of our institution's tele-ICU program, we conducted a phased retrospective study focusing on inter-hospital transfers.

METHODS

In response to a lack of structured and generalizable research in the field, the ICU Telemedicine Research Working Group charted organized methodologies for conducting research in telemedicine in 2010¹⁷. Our study methodology is based upon those recommendations, as described subsequently.

1. Pre Implementation ICU environment

Intensive care units of six hospitals within the Mayo Clinic Health system (MCHS), located in southern Minnesota and western Wisconsin, comprise the study sample. The vast majority of patients from these six hospitals that are referred for a higher level of care are transferred to Mayo Clinic, Rochester. We categorized these six hospitals into two tiers: those with more ICU resources termed Type 1 hospitals, and those without such resources, termed Type 2 hospitals (Table 1). The capabilities of the six hospitals were reviewed in retrospect and the categories decided a posteriori. We performed this stratification in order to better characterize the response of differentially specialized centers to our intervention.

2. The Telemedicine Intervention

Mayo Clinic, Rochester implemented a tele-ICU program in August, 2013 at the six hospitals under study. The monitoring unit is staffed 24/7 by board-certified intensivist physicians, and critical care trained registered nurses; advanced practice providers (NP's and PA's) trained in critical care were added on June 1, 2014. Our tele-ICU program does not function as a logistic center; the selection of patients admitted to the community hospital ICU is determined independently and solely by local providers. Once the patient is admitted to the local ICU, the telemedicine center acts as a 24/7 surveillance unit. The program utilizes an integrated electronic health record, electronic order entry and real-time video and audio monitoring and communication to assist in the management of adult ICU patients at the facilities under study.

3. Study Methodology

This is a phased retrospective observational study utilizing pre and post design to study trends of inter-hospital ICU transfers from peripheral hospital systems to the quaternary center at Mayo Clinic, Rochester before and after the institution of telemedicine ICU monitoring. The study has been divided into 3 phases:

1. Pre Implementation phase: January 1, 2012 to December 31, 2012
2. Transition Phase: January 1, 2013 to December 31, 2013
3. Post implementation phase: January 1, 2014 to December 31, 2014

The transition period was not included in the comparison periods to allow time for adoption of a complex system. All adult ICU admissions during the study period in any of the 6 specified community ICUs were included in the study.

4. Data Collection and Patient Selection

The Mayo Clinic Institutional Review Board approved the study protocol. The patient data was extracted, transferred and loaded into study databases from the Cerner electronic medical record system using multiple Crystal Reports¹⁸. All ICU admissions between 01/01/2012 – 12/31/2014 at the remote locations were identified using codes for location of each unit. These reports were then exported into Microsoft Excel 2013 and JMP®, Pro 11. SAS Institute Inc., Cary, NC, USA for data management. Demographic information and outcomes data regarding these admissions was abstracted from this dataset including ICU and hospital mortality, ICU and hospital length of stays, use of mechanical ventilation, etc.

In many instances, datapoints within the remote electronic health record used to calculate severity of illness scores (such as APACHE and SOFA) prior to transfer were absent or incomplete. We instead utilized these datapoints obtained after transfer to the quaternary center, where such information was readily available within the medical record (see below).

The process flowchart depicting the sequence of patient selection is depicted in Figure. 1. From the initial raw data (19,389 possible admissions), we excluded entries with missing and incongruent admission/discharge dates, patients less than 18 years of age, test patients, and cancelled encounters. We also excluded data from a hospital that joined the network during the follow up phase. The remaining 18,292 admissions were included in the final sample.

Potential transfers to Mayo Clinic were then identified using their discharge dispositions. Valid transfers to Mayo Clinic, Rochester were then recognized from this group as those who were identified as admitted to any ICU in Mayo Clinic, Rochester within 12 hours of their discharge time from the peripheral hospital ICU.

Following transfer to the Mayo Clinic Rochester destination, further outcomes data were obtained through the ICU Datamart, a data collection research database developed at the Mayo Clinic and validated for ICU based data searches¹⁹. These included hospital and ICU length of stays, severity indices (Acute Physiological and Chronic Health Evaluation – III score (APACHE III) and 24 hour Sequential Organ Failure and Assessment score (SOFA score), hospital and ICU mortality and code status. The 6 community ICUs are located within a distance range of 45 miles to 120 miles from Mayo Clinic, Rochester, and average travel time by road between 50 minutes to 2 hours. The window of 12 hours was chosen during data search to account for extra time spent during transport (air and/or ground) and charting as well as to exclude patients detected in Mayo Clinic, Rochester after this window, who were likely not direct ICU transfers.

5. Data Analysis

In data analysis, all continuous variables were summarized using median (25th, 75th percentile) and compared between time periods (pre versus post) using the rank sum test. Nominal variables were summarized using frequency counts and percentages and compared between time periods using the chi-square test. The analyses were performed overall and also separately for Type I and Type II facilities. In all cases, p-values ≤ 0.05 were used to denote statistical significance. The data base was analyzed using statistical software SAS 9.0, Cary, North Carolina, USA. Additional combinations of baseline mortality and postulated significant changes were also performed.

RESULTS

In the post tele-ICU period, there were 181 inter hospital transfers (3.03% of all MCHS admissions) to the quaternary center at Mayo Clinic, Rochester as compared to 153 (2.43% of all MCHS admissions) in the pre implementation period ($p=0.040$). Overall, the indices of severity of illness at arrival i.e., Acute Physiological and Chronic Health Evaluation – III score (APACHE III) and 24 hour Sequential Organ Failure and Assessment score (SOFA

score) following transfer were not significantly different in the two study periods. Also, the overall time spent in the community ICU and hospital before transfer to the quaternary center was not significantly different pre and post enhanced ICU implementation (1.3 ICU days both pre- and post-, $p=0.91$, Table 2). The in hospital mortality and ICU length of stay at Mayo Clinic, Rochester was not significantly different. A significant increase was seen in median hospital length of stay at Mayo Clinic from 6.4 days pre tele-ICU to 8.1 days post tele-ICU ($p=0.03$). As depicted in Table 2, no significant changes were seen in the distribution of patients who on arrival at Mayo Clinic, Rochester were full code (all resuscitative measures), do not resuscitate/do not intubate (DNR/DNI), comfort care measures and patients whose code status was not specified. The proportion of patients who moved to comfort care measures following transfer was also not significantly different between the two groups (Table 2).

We proceeded to study the same trends according to each hospital type. In Type 1 hospitals, with more advanced local expertise, there was no significant change in the number of inter-hospital transfers to Mayo Clinic, Rochester ($p=0.880$) (Table 3). There was also no difference in the demographics and severity indices of patients (APACHE III and SOFA scores) on arrival at Rochester. No significant change in mortality, hospital or ICU length of stay was seen post transfer. There was also no significant change in the time spent in community ICUs and hospital before transfer. Similarly, analysis of data on aggressive care limitations did not show any significant difference in the distribution code status of these patients on arrival at the quaternary center or subsequent change to comfort care status.

In Type 2 facilities, transfers to Mayo Clinic, Rochester increased significantly ($p=0.037$) (Table 4). Although their hospital length of stay after transfer was also significantly higher in the post tele-ICU period, severity scores, including APACHE III and SOFA scores on arrival at Rochester were not significantly different. In hospital mortality and ICU length of stay at the quaternary center were not significantly different from the pre tele-ICU period.

DISCUSSION

To our knowledge, this is the first study focusing on patterns of inter-hospital transfers following implementation of a tele-ICU program within a regional health system. Unexpectedly and contrary to a purported benefit of reducing triage from community to referral hospitals, we have found that the number of transfers to the referral center significantly increased after tele-ICU implementation, an outcome attributed almost entirely to transfers from type 2 hospitals¹⁶. This finding is not explained by an increased severity of illness of transferred patients within our sample, as suggested by similar overall APACHE and SOFA scores as well as ICU length of stay at the destination hospital before and after program implementation.

Like many ICU telemedicine systems, our program operates within the framework of a tiered regional health system²⁰, populated by variably-sized hospitals providing important front-end care to critically ill patients and a large referral center where the majority of patients are transferred when needs outstrip resources or expertise. In our model, an existing triage and transfer center, operating independently of the tele-ICU center, streamlines the

referral process, augmented by affiliated and readily available ground and air transport systems^{21–24}.

Depending upon the particular tele-ICU model and framework of the healthcare system, studies reporting important outcomes associated with program implementation are often conflicting. Reductions in mortality and length of stay reported by Breslow et. al. were not replicated in a larger, multi-hospital study^{10, 13}. In a subsequent turn, improvements in these outcomes were reported in a large study from the University of Massachusetts system²⁵. Experts from the same healthcare system participated in a collaborative report from the New England Healthcare Institute and the Massachusetts Technology Collaborative, which promoted four principal benefits of a tele-ICU program¹⁶. In addition to expected improvements in ICU mortality, length of stay and return on investment, the report also cited financial benefit to payors, attributable in part to the enabling of community hospitals to care for more complicated patients and avoid transfer to referral hospitals, citing a cost savings of \$10,000 per case. Our study would suggest that such outcomes should not be routinely expected with implementation of a tele-ICU program. In the context of the totality of the literature showing what can be substantial costs associated with the construction of such programs, further research and examination of financial models are needed and careful consideration by healthcare organizations is warranted²⁶.

How might the finding of increased transfers from type 2 hospitals be interpreted? It is possible that, within an integrated network where few barriers to patient transfers exist, there may be a bias towards transfer to a higher level of care when there is concern about patient acuity or risk of deterioration, referred to as a *transfer bias*. With tele-ICU implementation and the addition of an intensive care specialist to the care team who is located at the destination hospital, this transfer bias may be heightened and the pathway to transfer facilitated, particularly for hospitals without advanced onsite resources. A trend towards a shorter length of stay at the type 2 referring hospitals following tele-ICU implementation would support this theory (Table 4, 1.2 hospital days versus 1.4 days, $p=0.31$). Within the framework of acuity scoring tools, this finding has occurred without a measurable increase in patient severity of illness, supporting a transfer bias.

Some patients are transferred to a referral center along well-delineated pathways for a specific intervention, as in the case of percutaneous coronary intervention for ST-elevation MI, which would be considered high-value transfers, the rates of which wouldn't be expected to change following tele-ICU implementation. For patients without such indications, in the absence of changes in crude but important outcomes such as mortality or length of stay in a relatively small study sample such as ours, it is difficult to measure retrospectively whether there is value in transferring patients to a higher level of care. As a corollary, we attempted to measure what might be termed “futile” transfers, where at the destination hospital, there is a transition in the direction and/or goals of care. We assessed the distribution of initial goals of care (so-called “code status” or aggressive care limitations) for transferred patients and also transitions to comfort measures. We found the distribution of aggressive care limitations was similar before and after intervention. Also, the proportion of patients transitioned to comfort measures was not different in the two study periods.

We acknowledge some limitations to our study. Although we included our entire tele-ICU population over a defined one-year time period, the sample size is relatively small, raising the possibility that the study is insufficiently powered to avoid type II error. In this context, it should also be mentioned that, compared to the estimated national average rates of about 5%, the overall rates of transfer within our health system were comparatively low at only 2.4%, (type 1 at 1.7% and type 2 at 4.22%).^{1, 2} Over the observation period, the overall case mix at the type 1 hospitals decreased modestly, which could potentially negate an otherwise increased transfer rate from those hospitals. On the other hand, since by definition type 1 hospitals are resourced with a larger complement of subspecialty and ancillary services, the constant rate of transfers from type 1 hospitals associated with tele-ICU is not necessarily surprising. Finally, our inability to capture acuity data at the community hospital level might underestimate actual illness severity, which may have been modified by tele-intensivist-directed interventions executed prior to transfer. On the other hand, there may be complexities related to patient care not well captured by SOFA or APACHE, but which may factor into the decision to transfer the patient to the more resource-rich referral center. This concept is supported by the significantly longer overall hospital length of stay at the destination center in the post-implementation period.

CONCLUSION

We have found an unexpected increase in the rate of inter-hospital transfers associated with the implementation of a tele-ICU program. Higher rates of transfer occurred from less resourced centers compared to hospitals staffed with intensivists and more subspecialty resources. These findings are in contrast to previous reports suggesting reductions in such transfers with attendant financial benefits. Further studies are needed to determine if similar patterns are seen in a broader array of tele-ICU practice models.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Patient Selection

Table 1

Categorization of Type 1 and 2 Community Intensive Care Units

Variable	Type 1 Hospitals	Type 2 Hospitals
1. No. of hospitals	3	3
2. Geographical distance	73–115 miles	42–127 miles
3. Total ICU * Beds Covered (each hospital combined)	51	20
4. Bed Occupancy	40%	40%
5. Electronic Medical record utilization	Yes	Yes
6. ICU type	Medical	Medical
7. Onsite emergency surgical services	Yes	No
8. Onsite emergency cardiac catheterization services	Yes	No
9. Daytime onsite intensivist	Yes	No
10. Nocturnal onsite intensivist	No	No
11. Onsite medical sub specialties	Yes	No
12. Teaching status	Non-teaching	Non-teaching
13. Level of Tele-ICU involvement	Co-management	Co-management

* ICU = Intensive Care Unit

Table 2

Transfers to Quaternary Health Center from all Community Intensive Care Units.

Variable	Pre Implementation (N=153)	Post Implementation (N=181)	p-value *
No of transfers to Quaternary Center N(% transfers/total admissions)	153(2.43)	181(3.03)	0.040
Age, years median (25 th , 75 th)	66 (52, 75)	66 (56, 75.5)	0.255
Gender, n (%)			0.254
Male	89 (58.2)	94 (51.9)	
Female	64 (41.8)	87 (48.1)	
Type of Hospital, n (%)			0.044
Type I	76 (49.7)	70 (38.7)	
Type 2	77 (50.3)	111 (61.3)	
Hospital length of stay before transfer(days) median (25 th , 75 th)	1.3 (0.7, 3.2)	1.3 (0.6, 3.1)	0.912
ICU length of stay before transfer(hours) median (25 th , 75 th)	22.4 (6.5, 51.6)	19.6 (7.5, 51.2)	0.952
APACHE III Score on arrival median (25 th , 75 th)	52 (39.5, 68.5)	52 (40, 68)	0.875
SOFA SCORE on arrival median (25 th , 75 th)	5 (3, 7)	5 (3, 8)	0.112
Quaternary Center ICU length of stay(hours) median (25 th , 75 th)	46.0 (26.1, 95.1)	52.3 (24.6, 122.1)	0.737
Quaternary Center Hospital length of Stay(days) median (25 th , 75 th)	6.4 (3.8, 11.7)	8.1 (4.2, 15.1)	0.033
Type of Code Status on arrival, n (%)			0.745
Full Code	103 (67.3)	126 (69.6)	
Do Not Resuscitate/Do Not Intubate	15 (9.8)	21 (11.6)	
Comfort Care	2 (1.3)	3 (1.7)	
Not Available	33 (21.6)	31 (17.1)	
Code status change to Comfort Care, n (%) [†]	18 (15.2)	17 (11.6)	0.378
Quaternary Center In Hospital Mortality, n (%)	21 (13.7)	36 (19.9)	0.136

* Characteristics were compared using the chi-square test for categorical variables and the rank-sum test for continuous variables.

[†] Analysis includes only those whose code status on arrival was Full Code or DNR/DNI.

When calculating the percentage of transfers, the denominator was total number of ICU admissions in the MCHS facilities during the pre and post time periods.

Table 3

Transfers to Quaternary Health Center from Type 1 Facilities only.

Variables	Pre Implementation (N=76)	Post Implementation (N=70)	p-value *
No of transfers to Quaternary Center N (% transfers/total admissions)	76(1.70%)	70(1.74%)	0.880
Age, years median (25 th , 75 th)	63 (48, 68)	61 (47, 69)	0.878
Gender, n (%)			0.760
Male	47 (61.8)	45 (64.3)	
Female	29 (38.2)	25 (35.7)	
Hospital Length of stay before transfer(days) median (25 th , 75 th)	1.1 (0.5, 3.3)	1.9 (0.6, 4.1)	0.338
ICU Length of stay before transfer(hours) median (25 th , 75 th)	20.9 (8.3, 59.7)	23.9 (6.7, 72.1)	0.700
APACHE III Score on arrival median (25 th , 75 th)	67 (47, 84)	66 (46, 84)	0.998
SOFA SCORE on arrival median (25 th , 75 th)	4 (2, 8)	5 (3,9)	0.109
Quaternary Center ICU Length of stay(hours) median (25 th , 75 th)	51.2 (36.1, 140.4)	54.1 (26.3, 138.5)	0.948
Quaternary Hospital Length of stay(days) median (25 th , 75 th)	8.5 (5.5, 12.9)	8.8 (4.2, 17.0)	0.638
Type of Code Status on arrival, n (%)			0.395
Full Code	50 (65.8)	53 (75.7)	
Do Not Resuscitate/Do Not Intubate	7 (9.2)	3 (4.3)	
Comfort Care	1 (1.3)	2 (2.9)	
Not Available	18 (23.7)	12 (17.1)	
Code status change to Comfort Care, n (%)†	10 (17.5)	6 (10.7)	0.298
Quaternary Center In Hospital Mortality n(%)	13 (17.1)	15 (21.4)	0.507

* Characteristics were compared using the chi-square test for categorical variables and the rank-sum test for continuous variables.

† Analysis includes only those whose code status on arrival was Full Code or DNR/DNI.

When calculating the percentage of transfers, the denominator was total number of ICU admissions in the MCHS facilities during the pre and post time periods.

Table 4

Transfers to Quaternary Health Center from Type 2 Facilities only.

Variables	Pre Implementation (N=77)	Post Implementation (N=111)	p-value*
No of transfers to Quaternary Center N(% transfers/total admissions)	77(4.22%)	111(5.7%)	0.037
Age, years median (25 th , 75 th)	69 (56, 79)	71 (61, 80)	0.469
Gender, n (%)			0.160
Male	42 (54.6)	49 (44.1)	
Female	35 (45.4)	62 (55.9)	
Hospital Length of Stay before transfer(days) median (25 th , 75 th)	1.4 (0.8, 3.2)	1.2 (0.6, 2.8)	0.307
ICU Length of Stay before transfer(hours) median (25 th , 75 th)	24.7 (5.5, 48.7)	19.2 (8.3, 43.8)	0.927
APACHE III Score on Arrival median (25 th , 75 th)	64 (50, 86)	67 (55, 84)	0.348
SOFA SCORE on arrival median (25 th , 75 th)	5 (3, 7)	5 (3, 8)	0.465
Quaternary Center ICU Length of Stay, (hours) median (25 th , 75 th)	41.5 (24.0, 80.9)	46.1 (24.4, 105.0)	0.386
Quaternary Center Hospital Length of stay (days) median (25 th , 75 th)	5.2 (3.1, 9.7)	8.0 (4.2, 13.3)	0.003
Type of Code Status on arrival, n (%)			0.708
Full Code	53 (68.8)	73 (65.8)	
Do Not Resuscitate/Do Not Intubate	8 (10.4)	18 (16.2)	
Comfort Care	1 (1.3)	1 (0.9)	
Not Available	15 (19.5)	19 (17.1)	
Code status change to Comfort Care, n (%) [†]	8 (13.1)	11 (12.1)	0.851
Quaternary Center In Hospital Mortality, n (%)	8 (10.4)	21 (18.9)	0.111

* Characteristics were compared using the chi-square test for categorical variables and the rank-sum test for continuous variables.

[†] Analysis includes only those whose code status on arrival was Full Code or DNR/DNI.

When calculating the percentage of transfers, the denominator was total number of ICU admissions in the MCHS facilities during the pre and post time periods.