The Impact of ICU Telemedicine on Patient Outcomes in the Surgical Critical Care Setting: An Observational Study

Megan Steely
mestee2@uky.edu

Recommended Citation
https://uknowledge.uky.edu/dnp_etds/385

This Practice Inquiry Project is brought to you for free and open access by the College of Nursing at UKnowledge. It has been accepted for inclusion in DNP Projects by an authorized administrator of UKnowledge. For more information, please contact UKnowledge@lsv.uky.edu.
The Impact of ICU Telemedicine on Patient Outcomes
in the Surgical Critical Care Setting: An Observational Study

Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Nursing Practice at the University of Kentucky

Megan E. Steely, BSN, RN
Lexington, Kentucky
2022
Abstract

**Background:** In April 2020, the University of Kentucky (UK) implemented a division entitled the Enhanced Care through Advanced Technology Intensive Care Unit (eCAT ICU) to provide tele-critical care (TCC) services in all critical care areas at UK Healthcare. The eCAT ICU at UK HealthCare was the first TCC delivery system of its kind in the state of Kentucky. Use of TCC has been associated with improved patient outcomes and decreased costs.

**Purpose:** The purpose of this study was to analyze targeted outcomes in the surgical critical care population pre- and post-implementation of TCC at UK HealthCare. Specifically, the aims of this study included a before and after analysis of the impact of TCC on hospital mortality, ICU mortality, hospital length of stay (LOS), ICU LOS, ventilator days, and ICU readmission within 48 hours of discharge.

**Methods:** A retrospective case-control design was employed for this study. Statistical analyses including t-test for equality of means were performed to examine changes in patient outcomes over a three-month period before and after implementation of UK’s eCAT ICU in March 2020.

**Results:** All targeted patient outcomes displayed small increases from 2019 to 2020. However, none of these increases met the criteria for statistical significance but some findings are clinically significant.

**Conclusion:** All targeted outcomes increased (worsened) from 2019 to 2020. However, the COVID-19 pandemic likely confounded study findings. Replication of this research is recommended that controls for the confounding factors experienced during a pandemic. Future research should examine the longitudinal effect of the eCAT ICU on patient outcomes, including a cost/benefit analysis for institutions using this innovative technology.
Acknowledgements

I would first like to thank my advisor and committee chair, Dr. Sheila Melander, who provided critically important guidance and advice as I navigated my final year of this DNP program. I would also like to thank Dr. Candice Falls, committee member, and Dr. Julia Blackburn, who served as both a committee member and clinical mentor. As Director of Neuroscience Services and eICU Operations Manager. Dr. Blackburn’s assistance was invaluable when developing the design and framework for this DNP project.
Dedication

I would like to thank my family for their support. My daughter Lauren, and son Chase, have navigated this journey of graduate school side-by-side with me, while enduring its effects on their mom. Furthermore, we would have floundered many times without the support of my parents, Forrest and Sandra. Thank you. Lauren and Chase, this is for you: Know beyond a shadow of a doubt that you can achieve anything you set your mind to in this life. I love you and believe in you endlessly.
# Table of Contents

Acknowledgements ........................................................................................................... 1  
Dedication .......................................................................................................................... 2  
Background and Significance............................................................................................ 5  
Purpose & Aims.................................................................................................................. 8  
Theoretical Framework....................................................................................................... 8  
Review of Literature......................................................................................................... 9  
  Search Methods............................................................................................................... 9  
  Summary of the Evidence............................................................................................... 10  
  Gaps in Practice.............................................................................................................. 14  
Design ............................................................................................................................... 15  
Setting ............................................................................................................................... 15  
  Agency Description........................................................................................................ 15  
  Congruence with Agency’s Mission, Goals, and Strategic Plan...................................... 15  
  Stakeholders.................................................................................................................... 16  
  Site Facilitators & Barriers............................................................................................. 16  
Sample .............................................................................................................................. 16  
Procedure ......................................................................................................................... 17  
  IRB Approval & Data Collection .................................................................................. 17  
  Measures & Data Analysis............................................................................................ 17  
Results ............................................................................................................................... 18  
  Demographics............................................................................................................... 18  
  Findings.......................................................................................................................... 18
The Impact of ICU Telemedicine on Patient Outcomes
in the Surgical Critical Care Setting: An Observational Study

Background & Significance

The utilization of telemedicine in the intensive care unit (ICU) setting is a relatively new technological approach to the improvement of critical care delivery. Tele-critical care (TCC) is defined as the provision of critical care services by remotely located healthcare professionals using audio-visual communication technology (Lilly, McLaughlin et al., 2014). Multiple studies suggest TCC care services can improve outcomes and reduce healthcare costs (Al Omari et al., 2020; Becker et al., 2020; Chen et al., 2018; Fortis et al., 2014; Franzini et al., 2011; Fusaro et al., 2019; 2010; Kruklitis et al., 2014; Kumar et al., 2013; Lilly, McLaughlin et al., 2014; Lilly, Motkus et al., 2017; McCambridge et al., 2010). Until recently, no such services were based in the state of Kentucky. However, in April 2020, the University of Kentucky (UK) teamed with Royal Philips to implement their tele-health software platform eCareManager to improve critical care delivery to the patient population at UK HealthCare.

Operating remotely from the Clinical Command Center, the Enhanced Care through Advanced Technology Intensive Care Unit (eCAT ICU) provides services to the critical care populations at UK’s A.B. Chandler Hospital and Good Samaritan Hospital, with plans to eventually expand services to community and rural hospitals to improve critical care access and delivery to patients across the state (Philips, 2019). Services provided by the eCAT ICU currently include remote monitoring, application of advanced analytics that detect early signs of deterioration, and bedside audiovisual access to TCC critical care nurses and intensivists for direct clinical support as needed (Fusaro et al., 2019). Multiple studies have been performed on similar TCC delivery models with a focus on outcomes, such as mortality, length of stay (LOS),
complication rates, and costs (Al Omari et al., 2020; Becker et al., 2020; Chen et al., 2018; Fortis et al., 2014; Franzini et al., 2011; Fusaro et al., 2019; Goran, 2010; Kruklitis et al., 2014; Kumar et al., 2013; Lilly, McLaughlin et al., 2014; Lilly, Motkus et al., 2017; McCambridge et al., 2010). These outcomes are often complicated by confounding variables but the implementation of TCC has been frequently associated with decreases in ICU mortality, hospital mortality, ICU LOS and hospital LOS (Al-Omari et al., 2020; Becker et al., 2020; Chen et al., 2018; Deslich & Coustasse, 2014; Kohl et al., 2012; Lilly, Cody et al., 2011; Sadaka et al., 2013; Wilcox & Adhari et al., 2012; Willmitch et al., 2012; Young et al., 2011). These reduced rates have been attributed to the influence of TCC interventions that can promote care standardization, process improvement, and improved clinician support (Becker et al., 2020; Khunlerkit & Carayon, 2013; Lily, Cody et al., 2011; Venkataraman & Ramakrishnan, 2015).

The assessment of the financial impact of TCC services is complex, and it is difficult to perform cost analyses that accurately account for the many variables involved (Ries, 2016). Many studies theorize that institutional costs logically decrease with TCC associated outcomes such as reduction in LOS, complication rates, and staff turnover (Fortis et al., 2014; Franzini et al., 2011; Kruklitis et al., 2014; Lilly, Motkus et al., 2017). However, several studies have attempted to quantify the cost savings associated with the implementation of TCC services. For example, a hospital system in Illinois estimated $3,000,000 in savings due to reducing ICU LOS over a six-month period (Kruklitis et al., 2014). A large multicenter hospital system in the northeast reported $5,400 in savings per patient, totaling $25 million per year, after implementing TCC and noting a 20% reduction in LOS (Kruklitis et al., 2014). Other studies have assessed data from multiple centers and prior studies to evaluate cost effectiveness: Yoo et al. (2016) performed a meta-analysis and determined that TCC services are cost-effective under
most circumstances. Two other studies found that although individual institutional cost savings varied, TCC services proved to be cost-effective and all institutions recouped their respective costs of TCC installation within 12 months (Fifer et al., 2010; Lilly, Motkus et al., 2017). Although findings vary, there are multiple possible financial benefits to the implementation of TCC services.

In the future, TCC services will be expanded throughout the entire UK HealthCare network (Philips, 2019). Expanded TCC services will provide quick, direct access to experienced critical care nurses and intensivists when rural hospitals are the first point of contact for critical patients. In some situations, TCC will offer enough support to local providers to facilitate critical patients remaining at their local hospitals instead of being transferred to a tertiary or quaternary facility, reducing costs while ensuring high quality care. One hospital system in South Dakota reported over $1,000,000 in air transport cost savings achieved by managing patients in-house with the aid of TCC services instead of transferring critical to a higher level of care (Goran, 2010). In other situations, TCC optimizes initial resuscitation before critical patients are transferred to a higher level of care (Philips, 2019). In both scenarios, ready access to consultation with critical care specialists has the potential to improve outcomes for patients across the state of Kentucky.

Common barriers to TCC program success include unfamiliarity between bedside and TCC staff, leading to limited communication and lack of collaboration (Canfield & Galvin, 2018; Goran, 2012; Hoonakker & Carayon, 2018; Kruklitis et al., 2014; Krupp et al., 2021; Moeckli et al., 2013; Young et al., 2011). Additional barriers include lack of perceived utility, concerns over disruption of care, and apprehension over monitoring of bedside staff, leading to avoidant and resistant behaviors among bedside staff (Hoonakker & Carayon, 2018;
Kowitlawakul, 2011; Krupp et al., 2021; Moeckli et al., 2013; Young et al., 2011). However, interventions focused on building interpersonal relationships between TCC and bedside staff have been associated with increased acceptance, trust, communication, and collaboration (Moeckli et al., 2013; Hoonakker et al., 2017). Providing education that delineates the roles and responsibilities of staff and explains the benefits of TCC services has also been associated with increased staff acceptance and satisfaction (Canfield & Galvin, 2018; Kowitlawakul, 2011). Some examples of these interventions include combined staff meetings, site visits, and shared educational experiences (Goran, 2010; Kurklitis et al., 2014).

**Purpose & Aims**

The purpose of this study was to analyze targeted outcomes in the surgical critical care population before and after implementation of TCC at UK HealthCare. Specifically, the aims of this study included a before and after analysis of the impact of TCC on hospital mortality, ICU mortality, hospital LOS, ICU LOS, ventilator days, and ICU readmission within 48 hours of discharge in the UK Neurosciences and Trauma-Surgical ICU populations. Comparing metrics pre- and post-implementation of the eCAT ICU could potentially help quantify the value of TCC to the UK HealthCare patient population. Additional aims of this study included the identification of barriers to TCC processes and the development of interventions to address these barriers.

**Theoretical Framework**

The Promoting Action on Research Implementation in Health Services Framework (PARIHS) model served as the theoretical framework for this study. This framework is comprised of three elements: Evidence, context, and facilitation (Schaffer et al., 2013). The first element, evidence, refers to research findings that serve as the basis for an evidence-based
practice change (Schaffer et al., 2013). The second element, context, refers to examination of factors that affect acceptance of innovative practices, such as institutional leadership and culture (Schaffer et al., 2013). The third element, facilitation, represents the efforts of individuals within the institution who apply their unique skills and influence to promote evidence-based practice change (Schaffer et al., 2013). The PARIHS model outlines the progression of this study.

Bringing the eCAT ICU to UK Healthcare was an evidence-based practice change, and the literature review in this study highlights evidence supporting TCC services. Examination of barriers and development of interventions to promote staff acceptance of TCC is an example of context. The efforts of the author and all TCC and bedside staff who champion TCC services are representative of the third element of the PARIHS model, facilitation. Evidence regarding TCC was obtained through literature review and statistical analysis with the purpose of evaluating and promoting acceptance of TCC services provided by UK’s eCAT ICU.

**Review of Literature**

**Search Methods**

A literature review was performed utilizing the MedLine and CINAHL databases available through the University of Kentucky Libraries website. Key search terms included “ICU telemedicine,” “tele ICU,” “tele critical care,” “eICU,” and “Philips.” Additional search terms “outcomes,” “mortality,” “LOS,” “effectiveness,” “ventilator days,” “readmission,” “perception,” “barrier,” “attitude,” “acceptance,” “satisfaction,” “cost,” “cost analysis,” “financial,” and “savings” were then utilized in combination with the original key search terms. A total of 458 articles resulted and 37 were selected to be included in this study: Only articles written in English and including adult populations were included. Articles published prior to 2010 and including pediatric or mixed adult and pediatric population were excluded. Studies that
utilized a pre- and post-implementation design, studies at larger medical centers as opposed to critical access hospitals, and studies focusing on nurse perception as opposed to provider perceptions were selected. A review of the references contained within key articles also yielded additional pertinent studies. Sample sizes varied between the studies reviewed with the smallest being 1913 patients (McCambridge et al., 2010), and the largest single study including 118,990 patients across 32 hospitals (Lilly, McLaughlin et al., 2014). Several meta-analyses, cost effectiveness studies, and qualitative studies related to nurse acceptance of eICU interventions were also included in this literature review, which consisted of articles from 21 journals. The most frequently represented journals included the American College of Chest Physicians (CHEST), the Journal of Critical Care, and Critical Care Medicine.

**Summary of the Evidence**

When reviewing studies that compared patient outcomes before and after TCC implementation, the most consistent finding was a decrease in ICU mortality (Al Omari et al., 2020; Becker et al., 2020; Chen et al., 2018; Deslich & Coustasse, 2014; Fusaro et al., 2019; Kalb et al., 2014; Kohl et al., 2012; Lilly et al., 2011; Lilly et al., 2014; McCambridge et al., 2010; Sadaka et al., 2013; Wilcox & Adhikari, 2012; Young et al., 2011). Other frequent findings included decreased ICU LOS, decreased hospital mortality, no change in hospital LOS, and decreased hospital LOS (Al Omari et al., 2020; Becker et al., 2020; Chen et al., 2018; Deslich & Coustasse, 2014; Kohl et al., 2012; Lilly, Cody et al., 2011; Lilly, McLaughlin et al., 2014; McCambridge et al., 2010; Morrison et al., 2010; Nassar et al., 2014; Sadaka et al., 2013; Wilcox & Adhikari, 2012; Willmitch et al., 2012; Young et al., 2011). Studies also reported that TCC implementation was associated with decreased ventilator days, decreased ICU readmission rates, and decreased incidence of central line associated bloodstream infections (CLABSIs) and
ventilator associated pneumonia (VAP) (Al Omari et al., 2020; Kalb et al., 2014; Lilly et al., 2011; McCambridge et al., 2010). Tables 1 and 2 provide a visual summary of these findings.

Although no direct cause-and-effect relationship has been established, research suggests that improved patient outcomes have occurred in large part to TCC’s promotion of improved adherence to best practice protocols and care bundles (Kruklitis et al., 2014; Goran, 2010; Venkataraman & Ramakrishnan, 2015). Some of the most common protocols and bundles are related to venous thromboembolism (VTE) prophylaxis, stress ulcer prevention, sepsis protocols, cardiopulmonary resuscitation, daily spontaneous breathing trials, ventilator associated pneumonia (VAP) prevention, and central line associated bloodstream infection (CLABSI) prevention (Goran, 2010; Kruklitis et al., 2014; Venkataraman & Ramakrishnan, 2015). Incorporating the contributions of TCC nurses and providers into the interdisciplinary care team can result in improved delivery and quality of patient care, thus contributing to improved patient outcomes (Venkataraman & Ramakrishnan, 2015).

Other outcomes related to TCC implementation include reduced hospitalization costs and increased revenue, although findings vary. Several studies theorize that decreased hospitalization costs logically follow when mortality, LOS, readmission, and complication rates decrease (Fortis et al., 2014; Franzini et al., 2011; Kruklitis et al., 2014; Lilly, Motkus et al., 2017). Goran (2010) noted that TCC implementation has been attributed to decreased turnover of nursing staff, as well as fewer patient transports to facilities offering higher levels of care, thereby reducing institutional costs. Another study noted that shorter LOS related to TCC implementation allowed for increased case volumes and resulting increased hospital revenue, which further strengthens the case for TCC profitability (Lilly, Motkus et al., 2017). These savings and profits are difficult
to directly attribute to TCC implementation due to confounding factors such as variations in reimbursement and study designs (Lilly, Motkus et al., 2017).

However, some studies have attempted to measure both the savings provided by TCC services and the costs of TCC implementation with varying results. For example, one study determined it costs approximately $45,000 per bed to both implement the TCC system and provide TCC services for one year (Fortis et al., 2014), but a similar study determined that cost to be between $50,000-$123,000 per bed for the same initial services (Kumar et al., 2013). One study in this review reported the value of TCC services implementation per bed, with average results ranging from $3,000 saved per bed to an additional cost of $5,000 per bed (Kumar et al., 2013).

Other studies have offered more optimistic results. Yoo et al. (2016) determined that the implementation of TCC services is cost-effective under most circumstances, although results varied from “not very cost effective” to “cost saving.” One institution recouped all costs required to install their TCC services within 3 months of implementation (Lilly, Motkus et al., 2017), and another study found that three different hospitals all recouped their respective costs of installation within 12 months (Fifer et al., 2010). Furthermore, multiple hospitals reported increased revenue well beyond recouping initial costs. One academic medical center reported a $52 million increase in annual net revenue attributable to TCC services, and another academic medical center reported a $25 million increase in annual net revenue after TCC program implementation (Lilly, Motkus et al., 2017; Kruklitis et al., 2014). In summary, TCC services have been found to provide many financial benefits and have repeatedly proven to be cost effective, although these benefits are often variable and difficult to quantify (Ries, 2016; Yoo et al., 2016).
Several studies emphasized the necessity of staff engagement and support to optimize the potential benefits of TCC services (Beasley et al., 2020; Goran, 2010; Khunlerkit & Carayon, 2013; Venkataraman & Ramakrishnan, 2015). Researchers noted TCC services have the most impact in high acuity areas where TCC staff and interventions are readily accepted by in-house staff and providers (Beasley et al., 2020; Goran, 2010; Khunlerkit & Carayon, 2013; Venkataraman & Ramakrishnan, 2015). Goran (2010) emphasized that successful integration of TCC services requires the identification of barriers to staff acceptance, as well as implementation of strategies to address those barriers.

Multiple barriers to staff acceptance of TCC services have been identified in the literature. These barriers include lack of collaboration, limited communication, and lack of familiarity and mutual respect between bedside and TCC staff (Canfield & Galvin, 2018; Goran, 2012; Hoonakker & Carayon, 2018; Kruklitis et al., 2014; Krupp et al., 2021; Moeckli et al., 2013; Young et al., 2011). Other barriers include a lack of perceived usefulness of TCC services, concerns that TCC processes increase the workload of and reduce the autonomy of bedside nurses, concerns that TCC services distract from the provision of care, and apprehension over being monitored (Hoonakker & Carayon, 2018; Kowitlawakul, 2011; Krupp et al., 2021; Moeckli et al., 2013; Young et al., 2011). These attitudes and perceptions can lead to behaviors such as bedside nurses avoiding communication with, delaying communication with, or completely ignoring the TCC team (Kowitlawakul, 2011; Young et al., 2011).

Kruklitis (2014) stated that for a TCC program to be a success, TCC providers must remain helpful and approachable and bedside staff must embrace opportunities to engage with TCC services. Interventions to help achieve these behavioral goals focus on three main areas: Relationship building, communication, and education (Canfield & Galvin, 2018). Facilitation of
face-to-face interaction between TCC and bedside staff is recommended and encouraged (Goran, 2012; Hoonakker & Carayon, 2018; Young et al., 2011). Building relationships through interpersonal interactions increases familiarity and respect, promotes communication and collaboration, and alleviates apprehensions over being monitored (Moeckli et al., 2013; Hoonakker et al., 2017). Education on benefits of TCC services and education regarding roles, responsibilities, and expectations reassures staff that TCC interventions are intended to benefit patient outcomes and support nurses by enhancing, not interfering with workflow (Moeckli et al., 2013). Educating and supporting staff empowers them to successfully adapt to new technologies, accept change, and engage in new processes and workflows (Canfield & Galvin, 2018; Kowitlawakul, 2011). Goran (2010) suggested several interventions to provide education, improve relationships, and encourage communication between TCC and bedside staff, including: Meetings involving both bedside and TCC staff, visits to the remote TCC location by bedside staff, orientation programs in both areas that incorporate visits to the alternate site, shared continuing education experiences, and formal recognition programs that award excellent collaborative behaviors.

Gaps in Practice

The University of Kentucky implemented the Philips eICU program in the spring of 2020. The “eCAT ICU” became the first TCC program to be implemented in the state of Kentucky thus addressing the gap of lack of TCC services available to the critical care population at UK HealthCare. This study proposes interventions that help to quantify the effectiveness of TCC interventions at UK HealthCare through measure of quality metrics.
Design

This study utilized a retrospective case-control design to analyze quality metrics before and after implementation of the University of Kentucky’s eCAT ICU Program. The outcome metrics examined in this study include hospital mortality, ICU mortality, hospital LOS, ICU LOS, ventilator days, and ICU readmission within 48 hours of discharge.

Setting

Agency Description

This study used data from the University of Kentucky’s AB Chandler Hospital, a level one trauma center, quaternary referral center, and academic medical center. The population for this study included the Neuroscience Services ICU and Trauma/Surgical Services ICU patient populations. The Neuroscience ICUs are located on the 6th floor of Chandler’s Pavilion A, and the 7th floor of Chandler’s Pavilion A houses the Trauma-Surgical ICUs. Each floor in Pavilion A is divided into two towers (100 and 200), and there is one ICU located on each tower. These ICUs are named numerically by floor and by tower: 6.100, 6.200, 7.100, and 7.200 ICU. These four ICUs contain twelve beds each, totaling 48 ICU beds.

Congruence with Agency’s Mission, Goals, and Strategic Plan

UK HealthCare’s mission includes a commitment to research, education, and clinical care. More specifically, UK HealthCare aims to provide advanced patient care, serve as an information resource, and improve the healthcare delivery system. UK HealthCare’s values are as follows: diversity, innovation, respect, compassion, and teamwork, which have been coined “living DIRECT” (UK HealthCare, 2020). This study will analyze targeted outcomes related to UK HealthCare’s TCC delivery system using newly implemented technology and falls directly in line with its mission statement and values.
Stakeholders

The primary stakeholders for this project were the patients in the Neuroscience Services and Trauma/Surgical Services ICUs. Additional stakeholders included the Neurosciences, Trauma/Surgical and eCAT ICU nurses, providers, and administrators.

Site Facilitators & Barriers

The Director of Neurosciences Services/eICU Operations Director, provided valuable mentorship that was a key component in the development of this project. Another important facilitator was researchers at the University of Kentucky’s Center for Clinical and Translational Science (CCTS) who provided data extraction services using the CCTS Enterprise Data Trust. An inability to access patient data directly from the Philips eCareManager system via the CCTS service was a significant barrier in this study.

Sample

The target population for this study included all adult patients with critical care admission orders in the Neurosciences and Trauma-Surgical ICUs at UK HealthCare. Patients younger than 18 years old, patients older than 90 years old, transplant recipients, and patients for whom hospice or comfort care orders had been placed were excluded. The Neurosciences and Trauma-Surgical ICU populations were selected because they were among the first areas to go live with UK’s TCC services. Additionally, including the Neurosciences and Trauma-Surgical ICUs and excluding the Pulmonary and Cardiothoracic ICUs was an attempt to avoid confounding variables due to the COVID-19 pandemic. The service lines most represented by the study patient population included: Trauma Surgery, Emergency General Surgery, Neurosurgery, Neurology, Vascular Surgery, Oral Maxillofacial Surgery, and Otolaryngology. Pre-implementation data were abstracted from the EMR for the period of October - December 2019.
Dates for analysis of post-TCC implementation data included the period of October - December 2020.

**Procedure**

**IRB Approval & Data Collection**

Approval from the University of Kentucky’s Medical Institutional Review Board (IRB) was received on September 28, 2021 (see Appendix 1). Following IRB approval, a retrospective medical record review was performed. De-identified patient data were obtained through CCTS Data Extractions Services utilizing the UK Enterprise Data Trust. Data from qualifying patients receiving TCC were compiled into a spreadsheet and de-identified by removing names and replacing medical record numbers with randomized alphanumeric identifiers. The CCTS database analyst delivered the data via Research Electronic Data Capture (REDCap) Send-It, a method that uses multiple layers of password protection to ensure confidentiality and anonymity.

**Measures and Data Analysis**

The targeted outcomes of interest in this study included: Hospital LOS, ICU LOS, hospital mortality, ICU mortality, ICU readmission within 48 hours of discharge, and ventilator days. Descriptive statistics were performed using the following parameters: Location, year, age, gender, and admitting diagnosis. Statistical analysis was performed utilizing International Business Machines’ (IBM) Statistical Package for the Social Sciences (SPSS) software and included minimum, maximum, mean, and standard deviation for the following variables: Age, hospital LOS, ICU LOS, hospital mortality, ICU mortality, ICU readmission within 48 hours, and ventilator days. Frequencies were applied to gender and International Classification of Disease (ICD)-10 admission diagnosis codes. A two-sample t-test was performed to determine if
significant differences existed in any of the study’s outcome variables when compared by two groups (2019 pre-eCAT ICU vs 2020 post-eCAT ICU).

Results

Demographics

A total of 1490 patients met inclusion criteria for this study. The TCC pre-intervention cohort from 2019 (n = 731), and the 2020 post-intervention cohort (n = 759). Combined pre-intervention and post-intervention numbers were similar between ICUs: 6.100 ICU (n = 375), 6.200 ICU (n = 406), 7.100 ICU (n = 370), and 7.200 ICU (n = 339) (Table 3). In the 2019 pre-intervention group, the mean age for patients was 59.0 (SD=16.4), minimum age was 19, and maximum age was 89 (Table 4). In the 2020 post-intervention group, the mean age was 57.8 (SD=16.5), minimum age was 18, and maximum age was 89 (Table 4). In 2019, 38.3% of patients were female and 61.7% were male; in 2020, 42.7% were female and 57.3% were male (Table 4, Figure 1 and Figure 2). The ten most frequent admitting diagnoses were cerebral infarction (125), intracranial injury (84), non-traumatic intracranial hemorrhage (58), carotid stenosis (47), sepsis (42), intrathoracic injury (38), abdominal aortic aneurysm (35), non-traumatic subarachnoid hemorrhage (32) unspecified abdominal pain (25), and non-ruptured cerebral aneurysm (19), (Figure 3).

Findings

Descriptive statistics were used to determine the mean values of hospital LOS, ICU LOS, hospital morality, ICU mortality, ICU readmission within 48 hours, and ventilator days. Two-sample t-tests were used to determine if differences were statistically significant, using alpha = 0.05. Means for each variable increased from 2019 to 2020. These increases were small (Figure 3 and Figure 4), and none met the criteria of statistical significance as evidenced by a p value of ≤
0.05, as determined by the t-test equality of means. However, several parameters were clinically significant and neared statistical significance: Hospital LOS (p=0.064), ICU LOS (p=0.052), ventilator days (p=0.085), and hospital mortality (p=0.080) (Table 5).

**Discussion**

The results of this study were unexpected. The empirical literature suggests that implementation of TCC is associated with improved, or at least unchanged, quality outcome metrics. While quality outcome measures increased (worsened) for every variable, it is important to note that this study was conducted at the height of the COVID-19 pandemic. Despite efforts to reduce the effect of confounding factors, the conduct of this study in the midst of a pandemic likely influenced study findings.

UK HealthCare’s A.B. Chandler Hospital is an academic medical center, level 1 trauma center, and quaternary referral hospital that accepts patients from 9 surrounding states. Patient acuity at Chandler was historically high before the COVID-19 pandemic, and patient acuity increased following the onset of COVID-19. The first COVID-19 positive patient was admitted to UK in March 2020. As patient populations surged both at UK and in outlying hospitals due to the pandemic, UK was forced to suspend normal practices for accepting patients via both the Emergency Department and via direct admissions. Unprecedented demand for beds forced UK to restrict their admissions to only the highest level acuity patients and those requiring services not offered at other regional hospitals, such as extracorporeal membranous oxygenation (ECMO) or thrombectomy. Although this study did not include any COVID-19 positive patients, the increase in the high level of patient acuity from 2019 to 2020 presumably contributed to the worsened outcome metrics revealed by the statistical analysis.
This study’s unexpected results reinforce the need for further research to examine factors that contribute to patient outcomes and TCC intervention efficacy. As previously noted, TCC has been found to be most effective in environments of high acuity and high acceptance of TCC interventions by staff (Goran, 2010; Khunlerkit & Carayon, 2013; Venkataraman & Ramakrishnan, 2015). However, reluctance and tension are often noted among staff while adapting to the initiation of TCC programs (Canfield & Galvin, 2018; Goran, 2012).

Therefore, several interventions have been developed to provide opportunities for relationship building, communication, and education among the bedside and TCC staff at UK HealthCare. These interventions focus on increasing mutual familiarity among staff and providing education on TCC benefits to both staff and patients. Handouts with the names and pictures of TCC providers and nurses will be posted in all critical care areas to promote familiarity among bedside staff. Additionally, an open house has been scheduled at the eCAT ICU facility located on Alumni Drive to encourage face-to-face interaction and promote personal connections between bedside and TCC staff. Educational interventions include the dissemination of this study’s findings to both staff and administration at the open house and via email distribution. Future research is recommended to examine the effects of these interventions on bedside staff acceptance of TCC and patient outcomes.
Implications for Future Nursing Research

There is a significant need for further research. Although this study’s results were confounded by the impact of the COVID-19 pandemic, the literature supports a correlation of quality of patient care delivery and improved patient outcomes in settings with TCC support. The UK eCAT ICU will continue to offer TCC services to all critical care areas within UK HealthCare, and the plan remains to eventually expand access to these tele-critical care services beyond UK to other hospitals in the region and across the state. This study should be replicated in a manner that controls for the confounding factors experienced during a pandemic (or once the pandemic has subsided). Continued research on the same patient population past the first few years of the COVID-19 pandemic would shed light on the extent of confounding due to COVID-19. If patient outcomes showed statistically significant improvement beyond the pandemic, it could be assumed that this study's worsened outcomes were primarily due to COVID-19. Persistent lack of improved outcomes would underscore the need for further research to determine why UK’s patient population did not follow expected trends. Including patients over longer intervals, as opposed to the three-month intervals utilized in this study, could also prove enlightening.

Research into UK’s costs to implement and maintain the eCAT ICU could also prove beneficial, as well as research into institutional savings associated with the addition of TCC. This study suggests comprehensive staff education could be beneficial to promote acceptance and buy-in of TCC interventions. Qualitative research regarding nurse attitudes and confidence, perceived competency, and acceptance of TCC services would also be of interest. Furthermore, patient perspectives of the services provided by the eCAT ICU could also provide insights into the potential of this service to positively influence patient satisfaction.
Limitations

Limitations of this study include a moderate sample size and only including patients in the Neuroscience and Trauma-Surgical ICUs at a single center setting which limits generalizability of findings. Sample sizes reported in the literature review ranged from 1913 to 118,990 encounters, although several studies obtained data from multiple centers. Another limitation was the lack of data available directly from Philips eCareManager, and not available via CCTS. This prevented the analysis of metrics available only via Philips and not via UK’s electronic health record (such as the Acute Physiology and Chronic Health Evaluation [APACHE] scores utilized to predict mortality, which could not be included in this study). Although admitting diagnoses were included in the data query to CCTS, comorbidities were not included. Analysis of comorbid burden could have proven beneficial to better understand the reportedly worsened outcomes of the TCC post-intervention group. Finally, the comprehensive rollout of TCC services across UK HealthCare did not allow for comparison of ICUs with and without TCC support during the same timeframe. Due to the effects of the pandemic, metrics comparing ICUs both with and without TCC services during 2020 are recommended to determine if patient outcomes were impacted (or unchanged) by the pandemic.

Conclusion

The purpose of this study was to analyze targeted outcomes in the surgical critical care population before and after implementation of TCC at UK HealthCare. Outcome variables included: ICU mortality, ICU LOS, ventilator days, and ICU readmission within 48 hours of discharge. This study determined that all targeted outcomes worsened from 2019 to 2020, but it is reasonable to consider that the COVID-19 pandemic likely confounded the findings, and further research is needed to determine whether or not the eCAT ICU beneficially affects patient
outcomes. Additional research is recommended to evaluate the financial implications of the eCAT ICU and whether it appears to be a cost-effective approach in achieving quality patient care. Furthermore, multiple interventions to increase staff acceptance and buy-in of the eCAT ICU are underway. Further research is needed to determine whether or not efforts to promote staff acceptance of TCC services are beneficial.
References


### Table 1: Literature Review, Part 1

<table>
<thead>
<tr>
<th></th>
<th>Al-Omari et al., 2020</th>
<th>Becker et al., 2020</th>
<th>Chen et al., 2018</th>
<th>Deslich &amp; Coustasse, 2014</th>
<th>Fusaro et al., 2019</th>
<th>Kalb et al., 2014</th>
<th>Kohl et al., 2012</th>
<th>Lilly, Cody et al., 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital Mortality</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>ICU Mortality</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>↓</td>
<td>NO CHANGE</td>
<td>↓</td>
<td>NO CHANGE</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>ICU LOS</td>
<td>↓</td>
<td>NO CHANGE</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Vent Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>↓</td>
<td></td>
</tr>
<tr>
<td>Readmit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLABSI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>↓</td>
<td></td>
</tr>
<tr>
<td>VAP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>↓</td>
</tr>
</tbody>
</table>
### Table 2: Literature Review, Part 2

<table>
<thead>
<tr>
<th></th>
<th>Lilly, McLaughlin et al., 2014</th>
<th>McCambridge et al., 2010</th>
<th>Morrison et al., 2010</th>
<th>Nassar et al., 2014</th>
<th>Sadaka et al., 2013</th>
<th>Wilcox &amp; Adhikari, 2012</th>
<th>Willmitch et al., 2012</th>
<th>Young et al., 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital Mortality</td>
<td>![Down Arrow]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![Down Arrow]</td>
<td>![Down Arrow]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>![Down Arrow]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![Down Arrow]</td>
<td>![Down Arrow]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
</tr>
<tr>
<td>Vent Days</td>
<td>![Down Arrow]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
</tr>
<tr>
<td>Readmit</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
</tr>
<tr>
<td>CLABSI</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
</tr>
<tr>
<td>VAP</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
<td>![No Change]</td>
</tr>
</tbody>
</table>

### Table 3: Number of Patients

<table>
<thead>
<tr>
<th></th>
<th>All Units</th>
<th>6.100 ICU</th>
<th>6.200 ICU</th>
<th>7.100 ICU</th>
<th>7.200 ICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>731</td>
<td>190</td>
<td>198</td>
<td>182</td>
<td>161</td>
</tr>
<tr>
<td>2020</td>
<td>759</td>
<td>185</td>
<td>208</td>
<td>188</td>
<td>178</td>
</tr>
<tr>
<td>Total</td>
<td>1490</td>
<td>375</td>
<td>406</td>
<td>370</td>
<td>339</td>
</tr>
</tbody>
</table>
### Table 4: Age & Gender

<table>
<thead>
<tr>
<th>Year</th>
<th>Min. Age</th>
<th>Max. Age</th>
<th>Mean Age</th>
<th># Female</th>
<th>% Female</th>
<th># Male</th>
<th>% Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>19</td>
<td>89</td>
<td>59.0</td>
<td>280</td>
<td>38.3</td>
<td>451</td>
<td>61.7</td>
</tr>
<tr>
<td>2020</td>
<td>18</td>
<td>89</td>
<td>57.8</td>
<td>324</td>
<td>42.7</td>
<td>435</td>
<td>57.3</td>
</tr>
</tbody>
</table>

### Table 5: T-Test for Equality of Means

<table>
<thead>
<tr>
<th></th>
<th>Two-Sided P Value</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital LOS</td>
<td>0.064</td>
<td>-1.542</td>
</tr>
<tr>
<td>ICU LOS</td>
<td>0.052</td>
<td>-1.421</td>
</tr>
<tr>
<td>Ventilator Days</td>
<td>0.085</td>
<td>-1.381</td>
</tr>
<tr>
<td>Hospital Mortality</td>
<td>0.080</td>
<td>-0.029</td>
</tr>
<tr>
<td>ICU Mortality</td>
<td>0.729</td>
<td>-0.005</td>
</tr>
<tr>
<td>ICU Readmission Within 48 Hours</td>
<td>0.375</td>
<td>-0.019</td>
</tr>
</tbody>
</table>
Figure 1: Gender, 2019

- Male: 62%
- Female: 38%

Figure 2: Gender, 2020

- Male: 57%
- Female: 43%

Figure 3: Demographics: Most Common Admitting Diagnoses

- CVA
- Intracranial Injury
- ICH
- Carotid Stenosis
- Sepsis
- Intrathoracic Injury
Appendix 1: IRB Approval Letter

University of Kentucky | Office of Research Integrity
IRB, RDBC

XP Initial Review

TO: Megan Howard
Neuroscience Services
PI phone #: 859-227-0307
PI email: megan.steele howard@uky.edu

FROM: Chairperson/Vice Chairperson
Medical Institutional Review Board (IRB)

SUBJECT: Approval of Protocol

DATE: 9/28/2021

On 9/28/2021, the Medical Institutional Review Board approved your protocol entitled:

The Impact of ICU Telemedicine on Patient Outcomes in the Surgical Critical Care Setting: An Observational Study

Approval is effective from 9/28/2021 until 9/27/2022 and extends to any consent/assent form, cover letter, and/or phone script. If applicable, the IRB approved consent/assent document(s) to be used when enrolling subjects can be found on the approved application's landing page in e-IRB. [Note, subjects can only be enrolled using consent/assent forms which have a valid "IRB Approval" stamp unless special waiver has been obtained from the IRB.] Prior to the end of this period, you will be sent a Continuation Review (CR)/Annual Administrative Review (AAR) request which must be completed and submitted to the Office of Research Integrity so that the protocol can be reviewed and approved for the next period.

In implementing the research activities, you are responsible for complying with IRB decisions, conditions and requirements. The research procedures should be implemented as approved in the IRB protocol. It is the principal investigator's responsibility to ensure any changes planned for the research are submitted for review and approval by the IRB prior to implementation. Protocol changes made without prior IRB approval to eliminate apparent hazards to the subject(s) should be reported in writing immediately to the IRB. Furthermore, discontinuing a study or completion of a study is considered a change in the protocol's status and therefore the IRB should be promptly notified in writing.

For information describing investigator responsibilities after obtaining IRB approval, download and read the document "PI Guidance to Responsibilities, Qualifications, Records and Documentation of Human Subjects Research" available in the online Office of Research Integrity's IRB Survival Handbook. Additional information regarding IRB review, federal regulations, and institutional policies may be found through OIR's web site. If you have questions, need additional information, or would like a paper copy of the above mentioned document, contact the Office of Research Integrity at 859-257-9428.

see blue.

An Equal Opportunity University

35