

UTILIZING TELEMEDICINE IN THE ICU:
DOES IT IMPACT TEAMWORK?

by

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ABSTRACT

Adverse events and medical errors plague the healthcare system. Hospital acquired infections and teamwork are some of the biggest contributors to these adverse outcomes. In an effort to mitigate these problems, administrators and clinicians alike have developed mechanisms, such as telemedicine. However, little research has been conducted investigating the role of telemedicine on teamwork -- a fundamental component of quality patient care. The purpose of this study is to gain a better understanding of the impact of telemedicine on teamwork behaviors and subsequent teamwork attitudes and cognitions during a common medical task, rounds within the Trauma-Intensive Care Unit. To this end, rounds were conducted with and without telemedicine. During this 60 day period, 16 clinicians completed three surveys and 34 rounds were video recorded. The results of this study suggest that the relationships between teamwork attitudes, behaviors, cognitions, and outcomes are differentially impacted under conditions with and without telemedicine. More specifically, telemedicine is associated with an increase in attendance and communication density. Meanwhile, it does not significantly impact teamwork attitudes or cognitions. The primary implications of these findings indicate that telemedicine is not the solution for improving all teamwork elements but yet it is not a complete detriment either.

“An arrow can only be shot by pulling it backward. So when life is dragging you back with difficulties, it means that it’s going to launch you into something great. So, just focus and keep aiming.” – Author unknown

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LIST OF ABBREVIATIONS

1. Centimeter (cm)
2. Central Processing Unit (CPU)
3. High Definition (HD)
4. Hospital Acquired Infections (HAIs)
5. Hypothesis 1 (H1)
6. Hypothesis 2 (H2)
7. Hypothesis 3 (H3)
8. Hypothesis 4 (H4)
9. Hypothesis 5 (H5)
10. Hypothesis 6 (H6)
11. Hypothesis 7 (H7)
12. Hypothesis 8 (H8)
13. Hypothesis 9 (H9)
14. Integrated Services Digital Network (ISDN)
15. Intensive Care Unit (ICU)
16. Internet Protocol (IP)
17. Kilobits Per Second (kbit/s)
18. Liquid Crystal Display (LCD)
19. Master of Business Administration (MBA)
20. Mediator (med)
21. Not Applicable (N/A)
22. Page (p.)
23. Pages (pp.)
24. Personal Computer (PC)
25. Remote Presence Robot (RP-7)
26. Remote Presence Robotic System (RPRS)
27. Reverse Coded Survey Item (R)
28. Virtual Reality (VR)
29. Surgical Intensive Care Unit (S-ICU)
30. Transactive Memory System (TMS)
31. Trauma Intensive Care Unit (T-ICU)

CHAPTER: INTRODUCTION

Statement of the Problem

Advancements in equipment, procedures, and techniques continuously improve the quality of clinical practice, yet preventable medical errors and adverse events relentlessly plague patient care. For example, hospital acquired infections (HAIs) are a leading contributor to morbidity and mortality in the United States (Lucado, Paez, Andrews, & Steiner, 2010), with research estimating that there were approximately 1.7 million HAIs in 2002 in U.S. hospitals alone (Klevens et al., 2007) despite the notion that many HAIs are actually preventable. In addition, the Joint Commission (2009) continues to attribute problems with teamwork, specifically communication breakdowns, as one of the leading sources of preventable errors. In fact, error analyses have suggested that up to 70% of medical errors are a result of mishaps with teamwork (St.Pierre, Hofinger, Simon, & Buerschaper, 2011).

In an effort to combat these pervasive problems, policy makers, hospital administrators, and frontline providers have developed and implemented mechanisms, such as telemedicine. Telemedicine is generally defined as the use of electronic information and communication technologies to facilitate patient care over a distance (Latifi et al., 2007). Even though telemedicine was initially utilized in the 1970s, there has been resurgence since the 1990s. To demonstrate the prevalence in the twentieth century, a survey indicated that approximately one in four rural hospitals were utilizing telemedicine (Hassol et al., 1997), and telemedicine programs were implemented in a minimum of forty states (Perednia & Allen, 1995). Unquestionably,

however, this popularized mechanism has expanded exponentially as evidenced by every state in the United States as well as almost every country utilize telemedicine (Bashshur, 2002).

Even though research regarding telemedicine is promising, systematic reviews have indicated that the evidence on the role of telemedicine is inconclusive (Ekeland, Bowes, & Flottorp, 2010; Hersh et al., 2006a), and more credible studies are needed (Hailey, Ohinmaa, & Roine, 2004). In addition, current research needs to expand beyond the traditional patient (e.g., mortality) and financial (e.g., Intensive Care Unit (ICU) costs) outcomes to also include individual clinician and team processes (e.g., communication) and outcomes (e.g., mutual trust) in order to more definitively determine the impact of utilizing telemedicine to augment patient care.

Understanding the effect of telemedicine on teams is particularly important because quality clinical care is traditionally practiced in teams since individual providers lack the proficiency to delivery patient care alone (National Council of State Boards of Nursing, 2009), and patient care is too exhausting both mentally and physically for one person to endure (St.Pierre et al., 2011). Teamwork is especially prevalent in high-stakes environments (e.g., ICU) and complex tasks, such as patient management, with some suggesting that “teamwork is the ultimate prerequisite for successful treatment in a high-stakes medical environment” (St.Pierre et al., 2011, p. 196). In fact, teamwork is inherent in rounds, an essential component of patient management.

Rounds are a formal, daily meeting comprised of clinicians, typically residents, attending physicians, nurses, and ancillary providers, who discuss the status of a patient and evaluate the

treatment plan while educating junior clinicians accordingly. Traditionally, rounds were (and still are in many settings) conducted at the patient's bedside; in other words, the entire group of clinicians walks and discusses each case directly beside the patient. However, individuals (e.g., clinicians) can be carriers of pathogens, which is potentially a problematic situation for patients who already have suppressed immune systems as a result of other ailments (Donowitz, Wenzel, & Hoyt, 1982). Additionally, rounds conducted on the units are susceptible to environmental issues; that is, bedside rounds have more opportunities for interruptions and distractions, which can impact communication considerably (Alvarez & Coiera, 2005).

In an attempt to facilitate the mitigation of such infections by reducing additional and potentially unnecessary interactions between large groups of providers and patients and alleviate communication breakdowns as a result of environmental issues, clinicians began to conduct rounds remotely (i.e., separate from the unit). Even though remote rounds do have advantages (e.g., reduce interactions and possibly infections), they have the disadvantage of not having access to the patient visually as well as the most up-to-date vitals of the patient.

Leveraging the benefits of both types of rounds (face-to-face and remote), designers, clinicians, and administrators implemented technology that enables the accurate, efficient transmission of patient data as well as fosters visual and auditory communication between providers at distinct locations. Telerounding technology can consist of a mobile robot (that includes a camera, telephone, and microphone), and a corresponding control room (i.e., room where rounds occur separate from the patient unit) that contains monitors, speakers, and a microphone as well as a head set and camera for one-on-one verbal and visual communication.

These features afford for distributed interactions amongst clinicians while accessing real-time auditory and visual information of the patient, the vitals, and the environment fed from the telemedical robot to a shared monitor in the control room. This combined technology affords the ability to discuss cases and develop patient management plans at a distance (i.e., separate from the patient) while receiving the auditory and visual cues of the patient and the patient's vitals.

Irrespective of the approach and technology, daily rounds are not only fundamental for patient management, but they also are vital for medical education of residents and junior level physicians (Ahmed, 2002; Gonzalo, Masters, Simons, & Chuang, 2009). Although it is improbable that telerounding will become the norm in the near future, given the proliferation of technology as well as the importance of teams within the medical setting, and even more specifically rounds, it is fundamental to understand the mechanisms (i.e., telemedicine) that can substantially impact teamwork.

Purpose of the Current Study

The proposed study is to gain a better understanding of the effect of telemedicine on provider's teamwork behaviors and how these behaviors further influence providers' perceptions and attitudes towards their fellow team members (i.e., clinicians) during rounds within the fast-paced, high-stakes ICU environment. The targeted team constructs in this study are selected from a recent review conducted by Salas et al. (2009). It is important to note that this study is focused on uncovering the effects of telemedicine on team-related behaviors, attitudes, and cognitions among frontline providers within a particular unit. A unit, as defined by Nembhard and Edmondson (2006) is "a cross-disciplinary care team, consisting of all of the staff that

participates in delivering a specific domain of clinical care” (p. 946). Consequently, this study did not include clinical care workers that did not have access to participant in rounds (i.e., night staff) or administrative staff that primarily work within the ICU but did not directly interact with patients. Additionally, this study did not include patients as team members since the ICU consists of patients with extremely severe cases (e.g., gunshot wounds to the head, pedestrians getting hit by vehicles, etc.), and many of these individuals were not cognizant or even conscious.

Despite not including patients or administrative level staff, this study contributes to the scientific community by providing more evidence on how characteristics of the task or environment (i.e., telemedicine) impact team processes and outcomes. In addition, it provides a better understanding of the relationship between the rounding process and teamwork. In particular, it bestows information on how the differing rounding processes (e.g., telerounds) impact teamwork behaviors and attitudes. Furthermore, this study offers clues regarding the theoretical mechanisms underlying the connection between telemedicine and teamwork. Practically speaking, this study has substantial implications for improving the effectiveness of telerounding across a variety of departments as well as offer prescriptive guidance on how to appropriately utilize telemedicine during the rounding process to optimize teamwork.

CHAPTER TWO: LITERATURE REVIEW

Telemedicine

Definition

Although telemedicine, the physical tools as well as the definition, changes as technological advancements evolve, the term actually originates from the Greek word *tele*, which means at a distance and the Latin word “*mederi*”, which is defined as healing. Thus, the literal translation means healing at a distance. The term telemedicine, however, was coined by Thomas Bird in the 1970s and has been defined as “the practice of medicine without the usual physician-patient confrontation via an interactive audio-video communication system” (Bashshur et al., 2000, p. 614). Similar to other complex concepts, telemedicine too has several definitions, such as, “the use of electronic information and communications technologies to provide and support health care when distance separates participants” (Field, 1996, p. 16), “medical applications that use interactive video, typically for specialty or subspecialty physician consultants” (Field & Grigsby, 2002, p. 423), and “use of telecommunications technology for medical diagnostic monitoring and therapeutic purposes when distance and/or time separates the participants” (Hersh et al., 2006, p. 3), to name a few. See Table 1 for a list of various definitions.

Undoubtedly, these definitions have slight variations, yet it is evident that there are two common and defining characteristics of telemedicine. First, telemedicine inherently assumes distance or separation between two or more parties; and second, it utilizes telecommunication or information transmission technology (e.g., telephone, video, modem, etc.) to relay health information to foster clinical care (Bashshur et al., 2000). It should be noted though that participants no longer

explicitly apply to physician and patient interactions as Bird (1971) initially suggested; that is, the participants refer to the original relationship of clinician and patient as well as multiple clinicians or even a combination of clinicians and a patient.

Table 1. *Definitions of Telemedicine and Similar Terms*

Article	Term	Definition
Almazon & Gallo (1999)	Telemedicine	The direct/indirect investigation, monitoring, and management of patients and the education of patients/medical staff using systems that allow medical information transfer across a distance.
Anvari (2011)	Telemedicine	The utilization of medical information from sites separated by distance, through the use of electronic communication technology, in order to improve health-care and the education of the patient or health-care provider.
Baquet (1999)	Telemedicine	The use of advanced telecommunication technology to facilitate diagnosis, research, transfer patient data, and improve disease management from remote sites.
Bashshur (1995)	Telemedicine	The practice of medicine without a direct physician-patient interaction, but instead through remote interactive audiovisual communication technology. This remote healthcare can be used between a provider and a client, a provider to another provider, a provider to a computer, or a client to a computer.
Chung, Grathwohl, Poropatich, Wolf, & Holcomb (2007)	Telemedicine	The use of telecommunications to allow caregivers to interact with patients and/or other caregivers operating at remote locations.
Duchesne, Kyle, Simmons, Islam, Schmieg, Olivier, & McSwain (2008)	Telemedicine	The electronic transfer of medical data from one location to another. This data can include high resolution images, sounds, video, and patient records.
Guler & Ubeyli (2002)	Telemedicine	Practicing medicine at a distance using technology.
Hersh, Hickam, Severance, Dana, Krages, et al. (2006)	Telemedicine	The use of communication technology in the medical profession, in which the purpose is to diagnose, monitoring patients, or aid in therapy when distance and/or time separate the participants.
Iftikhar, Majid, Muralindran, Thayabaren, Vidneswaran, & Brendan (2011)	Telemedicine	Health care in which a care provider gains the ability to interact in an offsite environment through the use of virtual reality (VR) technology.
Nannings & Abu-Hanna (2006)	Telemedicine	The process of utilizing technology to communicate medical information between medical professionals and/or patients in different locations. This can include rapid access to remote medical specialist expertise, or the exchange of information (e.g. a voice, an image, medical records, or commands to a surgical robot, etc.). Telemedicine can be viewed as a means to facilitate quality clinical care or provide an avenue for

Article	Term	Definition
		continuing education for medical professionals in a convenient manner. It provides access to health care that transcends time limitations, social variables, and cultural barriers.
Smith (2007)	Telemedicine	The delivery of healthcare and the exchange of healthcare information across distances using “real-time” (aka synchronous) transfer of data, or “store-and-forward” (aka asynchronous) transfer of data.
Wootton (2001)	Telemedicine	A term describing any medical activity that involves the element of distance.

Categories

As a result of the evolutions in telemedicine, researchers have created taxonomies to better understand and organize the expansive field of telemedicine. Leveraging previous work, Tulu and colleagues (2005) proposed a taxonomy including two primary purposes of telemedicine: clinical and nonclinical. Expanding upon this taxonomy, Smith et al (2005) further delineated the dominant purposes of telemedicine into three overarching categories: clinical, educational, and administrative. Within the clinical arena, telemedicine is used to supplement patient care, such as diagnostics and surgery. Meanwhile, for educational purposes, telemedicine is used to augment lectures, conferences, workshops, and grand rounds. Finally, for administrative applications, it is used to arrange interviews, meetings, and correspondence between regional facilities. Irrespective of these aforementioned purposes, two distinct, separate categories have emerged – asynchronous and synchronous (Smith, 2007).

The first category, asynchronous applications, does not occur in real time but rather is known more commonly as “store and forward”. Traditionally, information and medical data (e.g., images, audio, and text) in store and forward tools are captured, stored, and subsequently

transmitted for later use (Hersh et al., 2006b). In fact, asynchronous applications do not rely on real time discussion at all, but rather, they depend on interpretations and diagnosis to be conducted later.

The second category, synchronous applications, is the type used in the present study, and it includes real-time interactions between two or more parties. Synchronous technology is most notably used for video-conferencing, telementoring, and distance education; and evidence repeatedly seems reassuring. Systematic reviews suggest that these tools are associated with maintaining the same level of care compared to traditional face-to-face interventions (Barak, Hen, Boniel-Nissim, & Shapira, 2008; Currell, Urquhart, Wainwright, & Lewis, 2010) and even enhanced outcomes, such as diagnosis (Hersh et al., 2002), patient satisfaction, and reduced length of stay (Hersh et al., 2001).

Unquestionably, one of the primary advantages of synchronous applications is that they afford real time, natural discussion and interactions (Loane et al., 2000), which enables requests to be addressed immediately and facilitate increased contact with other clinical experts. These real-time interactions are imperative for specific contexts that necessitate urgent yet accurate decision making and procedural skills, such as videoconferencing in emergency situations and surgical telementoring, which is characterized by a more prolific surgeon providing expertise to a colleague performing surgery at a separate location. Real time interactions, embedded within synchronous technologies, are also useful for building rapport between physicians and patients and family members. The physician-patient relationship is integral considering that the interactions that comprise these relationships are negatively associated with “doctor shopping”

(the act of finding an alternative care giver; Kaplan, Greenfield, & Ware, 1989) and positively related with medical information comprehension and recall (Ong, De Haes, Hoos, & Lammes, 1995), patient satisfaction, and compliance to treatment plans (Kaplan et al., 1989). Moreover, synchronous applications offer the capability of viewing live images (Smith, Bensick, Armfield, Stillman, & Caffery, 2005), and for patient indicators like heart rate or oxygen saturation levels, having a real time assessment of such indicators can be pivotal for diagnosis and patient management. In addition, synchronous telemedicine provides more opportunities for education (Grigsby & Sanders, 1998) by fostering relationships between senior and junior colleagues, enabling regional locations to collaborate and discuss difficult patient cases, and providing individually focused learning (Sable, Reyna, & Holbrook, 2009).

On the other hand, synchronous telemedicine is not without its drawbacks. For instance, it relies on real time interactions; thus, scheduling multiple individuals can be difficult and cumbersome. Moreover, real time interactive feed eliminates the ability to obtain and save hard copies of medical data. Although saved medical data may not be necessary for all contexts, it can become a worthwhile referent especially for complex cases. Also, such applications require greater technological and bandwidth requirements to be capable of producing a sufficient level of technical quality; in turn, visual images or auditory discussions may be reduced to merely acceptable levels (and potentially subpar) as opposed to optimal (Sable et al., 2009).

Telerounding Applications

Although telecommunication technology has a long standing place within medicine, the area of telerounding is a relatively recent field. Because the rounding process has dual purposes –

educate clinicians as well as facilitate patient management, studies have been simultaneously investigating the impact of telecommunication technology on the educational and clinical components of rounds. However, the current effort is not focusing on the educational or clinical aspects of telerounding but rather the attitudes, behaviors, and cognitions of clinicians associated with telerounding. Therefore, the research described below is applicable to the current study since it examines the patients' and clinicians' perceptions of telerounding. For a summary on all telerounding research, see Table 2.

Telerounding is generally characterized by a mobile robot maneuvering on the patient floor being controlled by someone in a remote room. The mobile robot "visits" the patient's bedside and transmits video and auditory data in real time to clinicians in a remote room. It should be noted, though, that one of the distinguishing features of telerounding is that the location of the patient is in the ward (Iftikhar, Majid, Muralindran, Thayabaren, & Vigneswaran, 2011). In general medical wards, telerounds encompass diagnosis as well as patient care and management. However, since surgical wards can be subdivided into pre-operative care and post-operative care, pre-operative telerounds are traditionally designated for diagnosis and planning; whereas, post-operative telerounds are primarily focused on post-surgical care and recovery (Iftikhar et al., 2011).

Despite the department, research regarding clinical care provider's perceptions is scarce, and behavioral research is practically nonexistent. Aiming to have a deep understanding regarding how patients would react and perceive telerounding, Ellison et al. (2004) assigned 85 patients to one of three conditions: standard daily bedside round visit, telemedicine round visit,

or a standard bedside visit plus a mobile robotic teleround visit. Their results suggested that participants in the telemedical robotic rounds had statistically significant higher patient satisfaction ratings compared to standard bedside rounds. Specifically, patients rated examination thoroughness, quality of information communicated, coordination of care, and physician availability as more favorable. In fact, anecdotal data indicated that patients not only recommend this technology be integrated into standard patient practices, but that they would actually prefer their own physician utilize telecommunication technology to “see” them if their primary physician is unavailable (Anderson, 2005; Buyske, 2007). One plausible explanation for the rationale underlying why patients prefer their own physician utilize a robot versus another physician is that a mobile robot still enables patients to maintain a personal link with their own physician despite the physical distance (Buyske, 2007). Similarly, clinicians also have reported positive reactions regarding the use of telemedicine technology to conduct rounds (Thacker, 2005). Both, nursing staff and physicians have attested that telerounding technology is easy to use, is an adequate substitute to bedside rounds, and should be instituted into standard practice (Kau et al., 2008; Petelin, Nelson, & Goodman, 2007). Although positive reactions from clinicians as well as patients are an indispensable component for adoption and integration into medical practice, research needs to extend beyond reactions to determine if telerounding positively impacts other provider attitudes as well as behaviors and cognitions.

Table 2. *Summary of Telerounding Research*

Article	Purpose	Description of Telemedicine	Sample	Key Findings
Allen, Sargeant, MacDougall, & O'Brien (2002)	Educational	<ul style="list-style-type: none"> • PC-based videoconferencing unit with a 53 cm monitor and a Sony EVI-D30 camera was used by the presenter. • PictureTel 4000 videoconferencing unit with a 69 cm monitor was used by the receiving site. • Rounds were used to give didactic presentations and discussions. 	Remote-site participants, physicians presenting rounds, and participants at the presenting site.	<ul style="list-style-type: none"> • Tele-rounds provided continuing medical education to community specialists. • Participants felt a stronger social connection to their colleagues due to the rounds. • Remote site participants were satisfied with content, educational value, and social interaction. • Participants were unsatisfied with the particular videoconferencing equipment used.
Agarwal, Levinson, Allaf, Makarov, Nason, & Su (2007)	Clinical	<ul style="list-style-type: none"> • Mobile robotic tele-mentoring system called RP-7 RoboConsultant was used. • The system was controlled by a remote laptop connected through broadband internet. • RoboConsultant was controlled by a senior surgeon from remote locations. • Robot functionality: navigation, zoom, ability to examine external/internal endoscope cameras, and telestation. 	Laparoscopic/ Endoscopic Urologic Surgery Patients	<ul style="list-style-type: none"> • The senior surgeon was able to effectively mentor and consult the local surgeon from a remote location. • The robot provided a means for remote presence in the operating room. • The robot was easy to operate.
Careau, Vincent, & Noreau (2008)	Educational	<ul style="list-style-type: none"> • Videoconference system with two 107 cm plasma screens. • Connected via IP at 384 kbit/s. 	Specialists involved in inter-professional care plan meetings for treatment of traumatic brain injuries.	<ul style="list-style-type: none"> • The participants achieved efficient teamwork with 96% productivity. • 2% of the round was dedicated to resolving technical issues. • Visual quality was good. Sound quality

Article	Purpose	Description of Telemedicine	Sample	Key Findings
				was rated poor.
Daruwalla, Collins, & Moore (2010)	Clinical	<ul style="list-style-type: none"> • Remote Presence Robotic System (RPRS) was used. • Rounds were performed by a single registrar from a remote laptop with secure wireless internet connection. 	Patients and staff nurses involved in orthopaedic postoperative care	<ul style="list-style-type: none"> • Patients who interacted with the RPRS had better care, and believed it should be a regular part of care. • Patients were satisfied with the video and sound of the robot. • All patients said that they would be comfortable having telerounds if their doctor were out of town. • Patient and Nursing staff had positive reactions to the RPRS.
Ellison, Pinto, Kim, Ong, Patriciu, Stoianovici, et. al. (2004)	Clinical	<ul style="list-style-type: none"> • Web-based Video Conferencing system and a robotic tele-rounding system were used. • The unit in the patient room included a laptop, a microphone, digital camera, WiFi, and Microsoft NetMeeting software. The attending surgeon controlled a base unit from a remote desktop system. • The robotic telerounding system consisted of identical equipment mounted on a remote controlled robot (In Touch Health). • Robot functionality: joystick interface controlled the ability to zoom, pan tilt, steer the robot, and focus the camera. 	Laparoscopic and Percutaneous urologic procedure patients	<ul style="list-style-type: none"> • Telerounding in daily bedside rounds increased patient satisfaction. • Physician-patient communication was fostered with the use of technology.
Ellison, Nguyen, Fabrizio, Soh, Permpongkosol,	Clinical	<ul style="list-style-type: none"> • Mobile robotic tele-rounding system used. • Robot characteristics: 60 inches tall, wheel-driven, 	Urological Procedure patients requiring	<ul style="list-style-type: none"> • Robotic rounds matched the success of normal bedside rounds after

Article	Purpose	Description of Telemedicine	Sample	Key Findings
& Kavoussi (2007)		<p>including a motor base unit, CPU, HD digital camera, flat screen monitor, and a microphone.</p> <ul style="list-style-type: none"> The attending physician controls the robot from a remote desktop computer with a joystick interface. 	hospital stay	<p>urological procedures.</p> <ul style="list-style-type: none"> Patient satisfaction, morbidity, and length of stay were identical to regular bedside rounding.
Gandsas, Parekh, Bleeche, & Tong (2007)	Clinical	<ul style="list-style-type: none"> Mobile robotic unit (RP7 from Intouch Health) used. Robot characteristics: 6 ft., 15-inch flat screen, 2 HD cameras, microphone, and a video conferencing system used to conduct live communication. A physician controls the robot from a remote station computer. RP7 functionality: receive patient radiographs, mobility, and audio-video streaming. 	Laparoscopic gastric bypass for morbidly obese patients	<ul style="list-style-type: none"> RP7 rounding significantly reduced patient length of stay. RP7 rounding allowed greater bed turnover (gain of \$219,578), and saved money as a result of early discharge (\$14,378).
Kau, Baranda, Hain, Bolton, Chen, Fuch, et al. (2008)	Clinical	<ul style="list-style-type: none"> Laptop computers (Macbook Pro) and video conferencing software (iChat AV) were used to conduct rounds. A nurse brought the computer to the patient, and a physician performed the remote rounding from a separate location. 	Routine Laparoscopic Urologic Surgery patients, physicians, and nurses.	<ul style="list-style-type: none"> 90% could easily communicate with the physician. All patients were comfortable using the system when their physician was not available directly and that it should be used regularly. All physicians and nurses could use the system easily. Physicians and nurses believed that it enhanced patient care, would be comfortable to use if needed, and that it should be used regularly. Video and audio quality was rated as excellent/very good (video (91.2%), audio (70.6%))

Article	Purpose	Description of Telemedicine	Sample	Key Findings
McCrossin (2001)	Educational	<ul style="list-style-type: none"> • Grand rounds conducted via multisite videoconference technology (up to 14 sites). • Running on ISDN lines at 128 kbit/s. 	Medical specialists at the host site and at remote sites	<ul style="list-style-type: none"> • The program was successful in providing mutual education to medical professionals for four years. • Remote centers without education programs were able to join in. • Most errors were overcome by good design and technical support.
Petelin, Nelson, & Goodman (2006)	Clinical	<ul style="list-style-type: none"> • Mobile Robotic unit (RP6) used. • Robot characteristics: 5'4" tall, 215 lb., rechargeable power supply, 360-degree mobility, flat panel screen, camera, microphone, and wireless antenna. • RP6 is controlled by a physician using a joystick interface from a remote location. • Robot functionality: screen tilt, zoom, picture taking, and telestration. 	Patients, Physicians, and Nurses at a Community Hospital	<ul style="list-style-type: none"> • Patients who were rounded using RP6 were discharged 4 hours earlier than normal (which in turn frees up beds) • Patient rounding was 3 x more efficient during nights and weekends. • Patients and staff were very satisfied with the experience with RP6.
Sargeant, Allen, O'Brien, & MacDougall (2003)	Educational	<ul style="list-style-type: none"> • Videoconferencing equipment located at each location. 	Academic health center and community specialists	<ul style="list-style-type: none"> • The academic center was willing to videoconference grand rounds, and the community specialists were willing to participate.
Sucher, Todd, Jones, Throckmorton, Turner, & Moore (2011)	Clinical	<ul style="list-style-type: none"> • Mobile robotic unit (RP7) used. • Robot characteristics: 6 ft. tall, 2 HD cameras, 15 inch flat screen lcd monitor, and a microphone. • RP7 is remotely controlled enabling the user live audio-video communication, multidirectional movement over a wifi network. 	Surgical Intensive Care Unit (SICU) patients and their families	<ul style="list-style-type: none"> • 92% patients/families felt comfortable with the robot. • 84% believed communication was easy. • 92% didn't feel that their doctor cared less about them due to the robot. • 92% supported the continued use of the robot.

Teamwork

According to Salas, Stagl, Burke, and Goodwin (2007), teamwork is defined as the “dynamic, simultaneous, and recursive enactment of process mechanisms which inhibit or contribute to team performance and performance outcomes” (p. 190). Due to innovative technologies, expanding global collaborations, and increased task complexity, teamwork is becoming the norm throughout organizations (Baker, Day, & Salas, 2006). Because of the prevalence of teams within organizations, there is an abundant amount of team research focused on competencies (Salas, Sims, & Burke, 2005), measurement (Cannon-Bowers & Salas, 1997; Salas, Rosen, Held, & Weissmuller, 2008), selection (Connerley & Mael, 2001), and training (Salas & Cannon-Bowers, 2000), to name a few. Although team research is gaining momentum within the medical field, there is exiguous research examining the connection between teamwork and telemedicine despite the exponential growth of telemedicine. As previously suggested, there are insufficient studies examining the relationship between telemedicine and teamwork, but there are a multitude of teamwork frameworks that describe the knowledge, skills, and attitudinal teamwork competencies essential for effective teams (e.g., Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995; Salas, Sims, & Burke, 2005b).

In fact, one recent review identified 138 models and frameworks that targeted specific facets of teamwork effectiveness or performance (Salas, Stagl, Burke, & Goodwin, 2007). Focusing on teamwork competencies, Salas et al. (2009) attempted to synthesize the literature by providing an updated, comprehensive paper detailing the pertinent teamwork attitudes,

behaviors, and cognitions. Their update expanded upon the theoretical work originally proposed by Cannon-Bowers et al. (1995) and incorporated significant strides made by empirical work. Salas and colleagues (2009) included an extensive list of competencies; however, investigating all of these competencies is beyond the scope of one study. Therefore, this effort will concentrate on a faction of the team related behaviors, attitudes, and cognitions that will likely be impacted by telemedicine. It could be argued that the team behaviors of attendance and communication and the emergent states of trust and transactive memory are fundamental for successful performance within any team context, and since telemedicine is currently being used in a myriad of situations, it is an important first step to investigate a select set of competencies in this context. The following sections will describe each of these exemplary competencies in further detail.

Behaviors

Clearly, individual clinicians do not perform in independent silos, but rather, they interact with other clinical care providers within the organization (Salas, Wilson, Murphy, King, & Salisbury, 2008). Indeed, medical teams are typically multidisciplinary in nature, and they must integrate and synthesize actions and information from various members and sources. These teamwork behaviors are the observable actions or verbal statements individuals display when interacting with other team members that are requisite for successful teams (Rousseau, Aube, & Savoie, 2006). Unquestionably, teamwork behaviors are integral for successful team outcomes and performance; thus, a number of reviews and frameworks have delineated the crucial team behaviors with one paper reviewing 29 frameworks that were dedicated to team behaviors

specifically (Rousseau et al., 2006). Even though most, if not all, teamwork behaviors are vital for successful performance, contribution (i.e., attendance) and communication can be argued as some of the most central components for teamwork.

Attendance

At the beginning of teamwork behavior is the simple notion of attendance; that is, before interdependent behaviors can even be performed, team members must attend in order to complete the team task. Team member attendance is generically referred to as being present for the team task. The level of attendance for team tasks, especially medical rounds is influenced by several factors. One of the factors is the way in which attendance is framed. For example, researchers have suggested that framing attendance as mandatory in turn reduces such attendance (Burke, Salas, Wilson-Donnelly, & Priest, 2004). Another study investigated the use of complimentary food on attendance of medical rounds, and the findings indicate that attendance was significantly higher if complimentary food was offered during rounds (Segovis et al., 2007). In fact, physician attitudes towards medical round attendance actually changed with physicians stating that they would be more inclined to attend rounds if complimentary food is offered. Finally, another study demonstrated that the physical location of rounds had a significant impact on attendance (Mueller, Litin, Sowden, Habermann, & LaRusso, 2003).

In addition to the aforementioned factors, telemedicine also can influence attendance. Telemedicine can serve as a visual cue that can prompt attendance. Since the telemedical robot is in the unit near the patients' bedsides even if rounds are occurring in a remote location, it serves as a "priming" mechanism for the healthcare providers on the unit. In essence, the robot

incidentally activates the cognitive and behavioral concepts associated with the robot itself and with rounding (Bargh, Chen, & Burrows, 1996). In other words, the robot serves as a visual cue within the unit, which prompts the actions of clinical care providers. Previous research has demonstrated that visual cues can consciously or even unconsciously alter behavior simply by being observed (Wheeler, Demarree, & Petty, 2005). For example, seeing and hearing cues that represent elderly people prompt both old and young individuals to walk more slowly (Bargh et al., 1996; Hausdorff, Levy, & Wei, 1999).

The underlying mechanisms of cues prompting behavior are actually twofold – ideomotor theory and auto-motive theory. The first, ideomotor theory, relies on the assumption that ideation can incite actions (Carpenter, 1893). Essentially, this theory states that ideas are capable of creating behavioral change even without conscious will or motivation (James, 1950). Furthermore, ideas can even trigger other related ideas and any associated behaviors of those related ideas (Devine, 1989). In other words, one cue can prompt an entire network of related concepts and behaviors. In fact, simply imagining a behavior triggers the same neural areas within the brain as performing the actual behavior (Dijksterhuis & Bargh, 2001). The next mechanism, auto-motive theory, also posits that behaviors can be prompted by ideas; however, this relationship is actually connected by an automatic generation of goals (Bargh, 1997). Goal accomplishments begin with cues and conscious activation and then transform to automatic and unconscious execution (Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trötschel, 2001). Said differently, cues within the environment initially enable conscious goal execution, but after multiple exposures, accomplishing goals becomes unconscious. Because the two theories operate

similarly, it is difficult to disentangle which theory is driving the connection between cues and behavior (Wheeler et al., 2005). Regardless of the underlying rationale, it is plausible that cues can actually strengthen behavior gradually (Bargh et al., 2001), which depending upon the circumstances can be quite advantageous.

In this particular context, visualizing the robot in the unit serves as a cue and reminder to nurses and other ancillary staff that may not typically attend rounds that not only are rounds being conducted at that moment, but they also are made aware of the exact patient case that is currently being discussed. Consequently, nurses and other staff may be more inclined to participate in rounds since they are able to dedicate the minimal time allotted for their distinct patient(s) as opposed to leaving the unit for an extended period of time to attend the entire rounding session. In sum, the presence of telemedicine (i.e., the mobile robot), in turn, will specifically facilitate teamwork behaviors, such as attendance within the rounds. With that, I hypothesize the following:

H1: Telemedicine will lead to more clinicians attending rounds within the T-ICU.

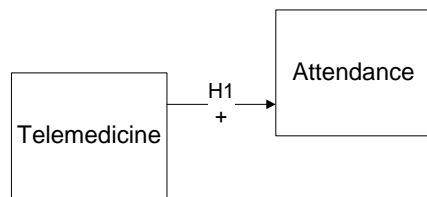


Figure 1. Hypothesis 1

Communication/Information Exchange

Communication is the verbal and nonverbal information exchanged between a sender and a receiver; and the patterns, content, and frequency are shaped by people, equipment, materials,

tasks, and the physical environment. Some argue that communication is bilateral; that is, communication is a joint activity where speakers monitor their own activities as well as the comprehension of the listeners, and even listeners are active participants by informing speakers of their comprehension (Clark & Krych, 2004). Researchers theorize that this exchange and comprehension is rooted in conversational grounding. Fussell et al. (2000) define grounding as, “the interactive process by which communicators exchange evidence” specifically within the context of conversation (p. 22). Said differently, conversational grounding is the mutual understanding between conversational parties that is established by the presence of shared information (Fussell, Kraut, & Siegel, 2000).

Shared visual information serves as a mechanism for conversational grounding (Burke & Murphy, 2007). One way conversational grounding is generated is through shared information in the spatial context – meaning between team members and the environment (Wolff, Roberts, Steed, & Otto, 2007). In other words, conversational grounding is established by visual information provided by the situation and task; however, the environment provides parameters about what can be discussed (Kraut, Fussell, & Siegel, 2003). Telemedicine broadens the scope of these boundaries by providing the rounding team with access to patients, their vitals, and other aspects on the unit. By comparison, remote rounds do not have visual access to the patient or current vitals. Consequently, remote rounds inherently have less common conversational ground within the spatial context; thereby, limiting the type and amount of task-based communication that can be exchanged.

Another way conversational grounding is generated is through the social context – meaning between collaborators (Wolff et al., 2005). In this particular situation, telemedicine also broadens the social-related visual information by affording for distributed communication via video. Telemedical technology affords for visual cues; such as gaze, posture, facial expressions, and nonverbal gestures. For example, gaze can denote what or whom a person is attending, head nodding can signify agreement or understanding, facial expressions can be indicative of confusion or surprise, and gestures can assist in conveying points (Isaacs & Tang, 1994). In fact, to demonstrate the automaticity in using nonverbal communication when speaking, individuals often use gestures even when talking on the phone (Isaacs & Tang, 1994). However, without access to these types of cues, that information is lost. Similarly, clinicians without access to telemedicine would forego those nonverbal cues since remote rounds do not have the technology that supports visual communication.

Irrespective of the spatial or social dimension, shared visual information lays the foundation for conversational ground by providing relevant contextual information (Burke & Murphy, 2007). Because the telemedical robot affords for a broader scope of task and social shared visual information, there is greater conversational ground in which to build task-based communication. Being able to leverage the conversational ground for task-based communication, as opposed to communication irrelevant to the task, enables cognitive resources necessary for communication to be minimized, which allows team members to direct such resources more appropriately (Smith-Jentsch, Zeisig, Acton, & McPherson, 1998). Ultimately, telemedicine offers more information (i.e., patients, vitals, and unit) during rounds, which increases the

breadth of conversational ground and in turn novel task-based communication frequency among team members during rounds.

Conversational ground is afforded by telemedicine via shared visual information, but telemedicine also enables more task-based communication by affording for more efficient communication patterns. In particular, telemedicine affords for communication to progress concurrently as opposed to sequentially. Concurrent patterns ensue when speakers and listeners can communicate simultaneously (Krauss & Weinheimer, 1966). For instance, if a resident asks a nurse a question via video, the nurse can respond in the affirmative by head nodding.

Conversely, sequential communication patterns manifest through turn taking (Traum, 1994). To illustrate, if a resident asks a nurse question via telephone, the nurse must wait until the resident has completed the question and then respond accordingly since the individuals must rely on verbal communication only and not visual communication. Clinicians who conduct remote room rounds must depend on verbal communication only via telephone since there are no means to communicate visually. Thereby, they are restricted to sequential communication patterns. On the other hand, clinicians who conduct telerounds are capable of sequential and concurrent communication since the technology affords for verbal and nonverbal communication.

Communicating so efficiently enables clinicians to engage in more task-based discussion without the expense of more time. That is, telemedicine affords for more efficient communication, which in turn allows for more task-based communication frequency by using sequential and concurrent communication patterns.

It should be noted though that task-based communication frequency refers to unique ideas. The technology utilized within the present study has more than adequate bandwidth and connectivity, so it is unlikely that there will be issues with transmitting data, which would necessitate repeating task-based information and thereby artificially inflating the task-based communication frequency. As a result, the concept of task-based communication frequency and any future references refers solely to unique ideas. Subsequently, I hypothesize the relationship as the following:

H2: Telemedicine will lead to a greater task-based communication frequency among the team members during rounds within the T-ICU.

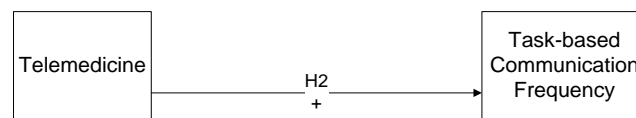


Figure 2. Hypothesis 2

As previously mentioned, telemedicine should concurrently, positively impact attendance and task-based communication frequency. However, it would be illogical to speculate that attendance would not also affect task-based communication. Research has demonstrated that team size influences team processes as well as team outcomes (Horwitz & Horwitz, 2007). Such research suggests that there is an effective size for teams that consist of only a sufficient amount of team members. In particular, the relationship seems to be curvilinear in that small teams, with very few members, tend to lack idea generation and diverse perspectives; meanwhile, very large teams are prone to conflict and lack cohesion (Carral, Forrester, Dawson, & West, 2001). Additionally, very large teams are apt to ineffective processes due to social loafing (i.e., exerting less effort when working in groups compared to working individually; Steiner, 1972) .

Subsequently, medium-sized teams have enough members to provide varying perspectives and diversity, but are still able to remain cohesive and have a manageable level of conflict and participation. Previous studies seem to indicate that there is an ideal team size for effective team processes, but there is little to specify the exact size.

This ambiguity may be attributable to the fact that the most effective and efficient team size is not a one-size-fits-all approach, but rather the most appropriate team size is dependent upon the specificities of the team, task, and the situation. Thus, within the parameters of the current study, it seems reasonable to speculate that the attendance of additional team members afforded by telemedicine will be positively impact team processes (i.e., task-based communication frequency). The attendance of additional members will likely consist of nurses and other ancillary clinical care workers present on the unit. Because these new team members have a different background, previous experiences, level of expertise, and interactions with patients; these clinicians can offer unique insights to the patient case. That is, since more individuals with different perspectives can participate in rounds, it is probable that there will be more task-based communication frequency. A larger yet manageable team consisting of relevant and appropriate members conducting rounds will be capable of sharing more unique information, which is vital in a team setting (Mesmer-Magnus & DeChurch, 2009). Given the relationships between telemedicine, attendance, and task-based communication frequency, I hypothesize the following below.

H3a: Attendance among the team members during rounds within the T-ICU will be positively related to task-based communication frequency among the team members within the T-ICU.

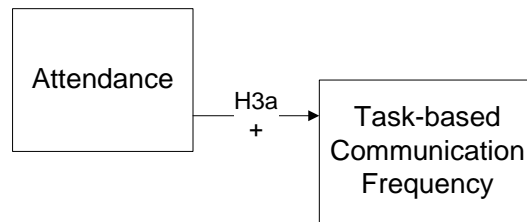


Figure 3. Hypothesis 3a

H3b: Attendance will partially mediate the effect of telemedicine on task-based communication frequency such that attendance will increase task-based communication frequency when telemedicine is present.

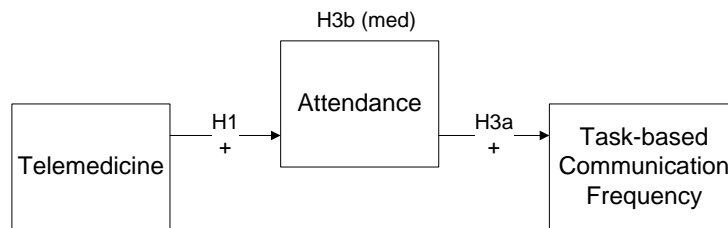


Figure 4. Hypothesis 3b

Attitudes

Attitudes are generally defined as, “an internal state that influences an individual’s choices or decisions to act in a certain way under particular circumstances” (Cannon-Bowers et al., 1995, p. 352). Said differently, attitudes are individual’s thoughts and feelings (Jones & George, 1998). Extensive theoretical and empirical work has hypothesized and demonstrated that

team-based attitudes influence team outcomes and performance (De Jong & Elfring, 2010; Lee et al., 2010). It should be noted though that the attitudinal competencies important and influential for teamwork can either be shared or simply compatible (Cannon-bowers & Salas, 1997). As the name suggests, shared attitudes refer to competencies that should be shared among the team members for successful team performance (e.g., trust and collective efficacy). Meanwhile, compatible attitudinal competencies can simply be similar among team members (e.g., team orientation) yet still achieve efficacious outcomes. As indicated above, trust is one of the shared attitudinal competencies, and it is debatably one of the most critical attitudes for effective teams in any context.

Trust

Research has continuously demonstrated that trust is a pivotal part of effective teams and teamwork as it is negatively associated with conflict (Han & Harms, 2010) and positively related team performance (De Jong & Elfring, 2010; Gilbert & Tang, 1998), to name a few examples. Considering it is important for all teams but especially within high-stakes environments and interdependent tasks, it has been extensively studied. Despite the importance of trust, it varies across time, relationships, and situations (Schoorman, Mayer, & Davis, 2007). As such, multiple definitions have been proposed by researchers, but for the purposes of this paper, I will define trust as “a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another” (Rousseau et al., 1998, p. 395). This definition has been repeatedly cited throughout the literature (e.g., Burke, Sims, Lazzara, & Salas, 2007; Lau & Liden, 2008; Weber & Weber, 2001), and it is also comprehensive in that it

includes elements of vulnerability, positive expectations of outcomes, and the motivations and intentions of others. To elaborate, vulnerability is an important note, as being vulnerable and open to risk is a mandatory characteristic of trust across all settings and relationships. The level of risk, though, will impact not just the likelihood in risk engagement, but it will also impact the types of cues in which trustors will concentrate, such as trustee's behavior in high risk situations (McKnight, Cummings, & Chervany, 1998). However, it should be noted that trust does not actually entail taking the risk but rather a willingness to engage in risk (Mayer, Davis, & Schoorman, 1995; Schoorman et al., 2007). Because trust involves a level of vulnerability and risk, it also inherently entails a level of uncertainty. This uncertainty ties into the second important notion of trust, maintaining positive expectations about outcomes despite the ambiguity. When trust is present among parties, there is an expectation of certain positive outcomes (Bhattacharya, Devinney, & Pillutla, 1998; Dirks, 2000). These expected outcomes relate to the third component, the motivations and intentions of others, which is simply the belief or realization that the other party does not aim or seek to be harmful (Butler, 1991; Gambetta, 1998; Rousseau, Sitkin, Burt, & Camerer, 1998).

All of these elements have the underlying theme that trust involves at least two parties – the trustor and trustee. According to Mayer et al. (1995), there are factors within each party that substantially impact the type and level of trust. For example, one particularly noteworthy characteristic of the trustor is propensity to trust. Propensity to trust is considered the baseline level of trust and is the extent to which an individual is willing to trust others (Burke et al., 2007). Although it varies according to one's experiences, personality, and cultural background

(Hofstede, 1980), propensity to trust is presumed to be a stable individual difference that influences the development of trust. It is considerably influential under certain circumstances, such as at the beginning of a relationship (Schoorman et al., 2007), when there is insufficient information available (McKnight et al., 1998), or when the trustworthiness of an individual is ambiguous (Gill, Boies, Finegan, & McNally, 2005). Interestingly, though, propensity to trust explains less variance within trust compared to characteristics of the trustee, specifically trustworthiness (Scott, 1980). Trustworthiness is largely characterized by ability and benevolence (Mayer et al., 1995). Ability is essentially the competence or skill necessary to accomplish a specific task or goal (Sitkin & Roth, 1993). This ability is not homogenous across all domains, but rather, it is task and situation specific. For example, a radiologist could be quite skilled at identifying problematic cues within an x-ray film; however, this same individual would likely have little ability in performing cardiac surgery. Meanwhile, benevolence pertains more to motivation, and it generally refers to the extent to which one has the desire to do “right” by the trustor (Jarvenpaa, Knoll, & Leidner, 1998). Both of these elements within trustworthiness (i.e., ability and benevolence) closely align different aspects of trust (i.e., cognition and affect; Levin & Cross, 2004).

Even though both cognition and affect are prevalent in the trust literature, many definitions and models of trust primarily conceptualize trust as unidimensional (i.e., cognitive; (Castelfranchi & Falcone, 2000; McKnight et al., 1998). Other researchers disagree with this approach and regard trust as multidimensional – consisting of cognitive and affective components. Cognitive-based trust is grounded in knowledge and information; in essence,

rationale, logic, and data serve as the basis for the decision to trust (McCallister, 1995). Conversely, affective-based trust is traditionally characterized through interpersonal bonds, connections, and relationships (McCallister, 1995). Emotions alter how individuals perceive, interpret, and evaluate experiences (even emotions unrelated to the person or task at hand) thereby impacting trust (Dunn & Schweitzer, 2005). In particular, emotional ties can impair judgment and lead to taking unfounded risk (Weber, Malhotra, & Murnighan, 2005). The underlying mechanism is that emotions, especially positive emotions, induce fondness and attachment, which ultimately enhances the feeling that another party is trustworthy (Williams, 2007).

Regardless if it is affective- or cognitive-based trust, traditional views of trust development posit that it is formed gradually over time (Lewicki & Bunker, 1995) due to some of the primary drivers (i.e., communication and social exchange). Undoubtedly, communication and the frequency of personal interactions modify trust substantially (Hung, Dennis, & Robert, 2004). According to Kramer (1999), “trust between two or more interdependent actors thickens or thins as a function of their cumulative interaction” (p. 575). In essence, the frequency of interactions and communication allow people to demonstrate their knowledge and abilities as well as build rapport and strengthen relationships (Webber, 2008). From a cognitive stance, these repeated interactions create a database of accumulated knowledge and behaviors in which trust assessments are formed (Hung et al., 2004). Trustors cull information by making observations of trustee’s behaviors under variant conditions (Williams, 2007). Indeed, this database allows trustors to make inferences and predictions regarding a trustee’s motivations, intentions, and

behavior, and any deviations in trust are based upon corroboration from positive or negative outcomes (Hung et al., 2004; Kramer, 1999; Lewicki & Bunker, 1995). From an affective perspective, social exchanges and interactions invoke feelings that alter fondness and attachment (Williams, 2007). Furthermore, positive interactions induce understanding and cooperation through helping and prosocial behaviors. Such behaviors are indicative of benevolence, a key facet of trust, by enhancing emotional support and reducing reservations associated with opportunism and ostracism (Williams, 2007).

The type and quality of interactions are highly dependent upon the information shared during such exchanges; that is, social interactions are simply a medium to foster communication. In fact, according to Ferrin (2003) communication characteristics (e.g., openness) are a significant determinant of trust; thus, communication is particularly foundational for trust development within the team context (Chowdhury, 2005). In general, communication provides a means to learn about a trustee's reputation, know and understand a trustee's integrity, and predict the behavior of a trustee (Lewicki, Tomlinson, & Gillespie, 2006). It serves as a means to engage in reciprocity of cooperation and exchange information and experiences (Kramer, 1999). Affectively, communication provides possibilities of demonstrating emotional support, care, and concern; and cognitively, communication affords for opportunities to exhibit competence and ability reliably. In addition, teams that communicate about the task, goal progression, and any potential obstacles will facilitate trust in that expectations are clearer and outcomes are less ambiguous (Webber, 2008).

Indeed, there is evidence to suggest that communication is paramount to trust; however, there are also factors that can erode trust (Kramer, 1999). For instance, technology designed to monitor trustees impedes motivation because it imparts a message that they are not trusted by the trustor, which produces low trust in return (Cialdini, 1996). However, in this context, the technology is being used to provide additional cues about patients not to monitor actions of clinicians. Therefore, I would not anticipate that the way technology is being used in this instance would negatively impact trust. Ultimately, the repeated interactions, shared information, and open communication among the clinical care providers will have an impact on trust. Therefore, I hypothesize the following:

H4a: Task-based communication frequency among the team members during rounds within the T-ICU will be positively related to cognitive-based trust among the team members within the T-ICU.

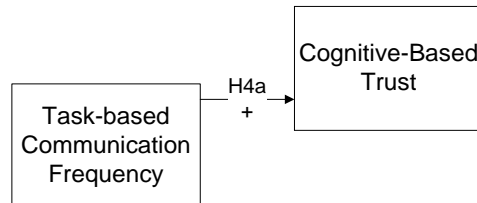


Figure 5. Hypothesis 4a

H4b: Task-based communication frequency will fully mediate the effect of telemedicine on cognitive-based trust such that higher task-based communication frequency will lead to higher cognitive-based trust when telemedicine is present.

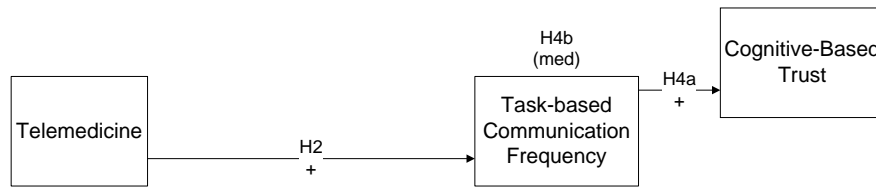


Figure 6. Hypothesis 4b

Cognitions

Team cognition is the knowledge at the team level to perform the necessary tasks to accomplish the shared goal (Cannon-Bowers et al., 1995). According to the knowledge approach conceptualization, it is created from the interconnections of individual knowledge as well as team behaviors (Wildman, Fiore, & Salas, 2009); that is, efficacious team cognition is a result of team process behaviors (e.g., communication). In other words, team cognition is not simply aggregated individual knowledge, but rather, it is an emergent structure that arises from cognitive exchanges among the team (Cooke, Salas, Kiekel, & Bell, 2004). Since many team tasks involve functions, such as problem solving, decision making, and pattern recognition, team cognition is fundamental for team performance. In fact, according to a recent meta-analysis, cognition accounted for incremental variance of team performance even above and beyond affect (i.e., motivation) and behavior (DeChurch & Mesmer-Magnus, 2010). Within this meta-analysis, a transactive memory system (TMS) was one of the central components within the overarching dimension of team cognition. The following section will detail transactive memory systems further.

Transactive Memory Systems

A transactive memory system is an interrelated set of individual memory systems (Wegner, 1986). In its most basic form, TMS is knowledge about who knows what (Ren &

Argote, 2011). To better discern transactive memory systems, Lewis and Herndon (2011) define it as “the shared division of cognitive labor with respect to encoding, storage, and retrieval” of information (p. 1254). These complex cognitions are actually comprised of two distinct factors – processes and structures (Ren & Argote, 2011). The first component, processes, are the mechanisms teams utilize to encode, store, and retrieve pertinent information (Lewis & Herndon, 2011). The second core component of TMS, structures, refers to the shared and differentiated team cognitions. More specifically, the shared cognition is the commonly held knowledge representations; meanwhile, the differentiated cognition is the divisible knowledge dispersed to each team member (Ren & Argote, 2011). Shared knowledge is beneficial in that it provides commonality on where information is located, which affords for quick and efficient retrieval (Ren & Argote, 2011). Conversely, differentiated knowledge is advantageous because it provides diverse yet specialized expertise (Pearsall, Ellis, & Bell, 2010). Differentiated knowledge reduces wasteful cognitive effort by avoiding any overlapping and redundant information among individuals (Peltokorpi, 2008). At the same time, differentiated knowledge also minimizes cognitive workload by allowing individuals to excel in their respective domain (Hollingshead, 1998). Consequently, effective transactive memory systems include a shared understanding of where information is located, yet sufficient specialized knowledge to offer novel and valuable insights (Sharma & Yetton, 2007). These two core elements of TMSs dynamically evolve since the processes become more refined as the structure develops (Lewis & Herndon, 2011; Pearsall et al., 2010).

Because TMSs are dynamic and evolving, they have the capacity to shift as modifications are made to the team. Furthermore, since TMSs do not rely on one specific team member but rather the team as a network, it is plausible that the TMS would be impacted by team membership change or turnover. In a thorough review of transactive memory systems, Ren and Argote (2011) discuss the implications of such a situation (i.e., team membership change). The authors suggest that when a member departs, the remaining team members no longer have access to that particular knowledge-base (within that team member), which can lead to detriments in the TMS; however, decrements are not inevitable as long as turnover is limited, and the team remains fairly stable, or the incoming team member possesses similar expertise as the previous team member. A new team member who can fill the gap created by the previous departure enables the TMS to remain intact and not have to be restructured. Conversely, even in some instances when a former member is not readily replaceable, a new individual may have a different knowledge set, which can positively affect the TMS if there are additive qualities of this new member's expertise, and the team can adapt accordingly.

As the team's lifespan progresses over time, these potentially worthwhile cognitions (i.e., transactive memory systems) become more sophisticated with communication being an integral component (Hollingshead & Brandon, 2003). Communication is necessary during encoding (i.e., registering information within memory) since the information is discussed as it is incoming, and this discussion gives team members the opportunity to raise questions and concerns as well as assess others' expertise (Ren & Argote, 2011). Communication can actually be particularly advantageous, especially compared to perception alone, because it serves as a form of rehearsal,

which is an effective mechanism for successful memory processing (Hollingshead, 1998; Wegner, 1986). Moreover, this communication also facilitates encoding by offering cues (Ren & Argote, 2011) and fostering a shared representation through verbalizing established associations (Hollingshead, 1998). Communication provides opportunities for team member's to exhibit his/her knowledge (Brandon & Hollingshead, 2004); in turn, this communication allows the other team members to get a better understanding of each member's respective expertise, which facilitates the process of distributing knowledge amongst the team (i.e., encoding; Hollingshead & Brandon, 2003).

In addition to encoding, communication is also requisite and even beneficial for collective recall (i.e., retrieval of information from the team's memory). More specifically, communication, probes and descriptions in particular, offers cues that can trigger knowledge and ultimately aid retrieval (Hollingshead, 1998). Furthermore, communication can provide a foundation for context (Hollingshead & Brandon, 2003). Considering that all team and tasks are characterized by particular information, vocabulary, and tones; communicating more frequently enables teams to better recognize these intricacies allowing teams to develop a better TMS. Understanding these intricacies permits team members to solicit knowledge in a way that is understandable and facilitates the ability to utilize cues to foster accessibility (Hollingshead & Brandon, 2003).

Given the importance and benefits of communication, researchers have begun to investigate what facets of communication in particular are related to TMS. Both field and simulated studies have found evidence indicating that there is a positive association between

frequency of communication and TMS emergence. In particular, Lewis (2004) conducted a field study with MBA consulting teams, and the results suggest that teams that communicated face-to-face more frequently, especially during the initial phases of the task, had an improved TMS. Similarly, Kanawattanachi and Yoo (2007) also found that more frequent task-oriented communication during the early stages of the project led to enhanced aspects of TMS. Additionally, Jackson and Moreland (2009) demonstrated that communication frequency was important for a strong TMS; however, the medium of communication (i.e., face-to-face or not) was unimportant for TMS. Meanwhile, in the simulated environment, Palazzolo and colleagues (2006) found that communication density (i.e., more frequent task-related communication) was strongly and positively related to well-established TMSs. Even in a longitudinal study, He et al. (2007) found that software development teams with more frequent communication positively affected TMS.

Interdependent team members are motivated to communicate since the tasks involve sharing information to accomplish the objectives (Palazzolo, Serb, She, Su, & Contractor, 2006). Some posit that there are several mechanisms underlying the relationship between communication frequency and TMS. One is that communication affords for encoding, storage, and retrieval by providing opportunities for rehearsal (Hollingshead, 1998). In addition, more communication offers more occasions for individuals to learn about their fellow team members in general as well as their knowledge set (Kanawattanachai & Yoo, 2007). Peltokorpi and Manka (2008) argue that communication is the most effective means to identify expertise since indirect

means (i.e., third party information) can be exaggerated or inaccurate. As a result, I hypothesize the following:

H5a: More task-based communication frequency among the team members will positively lead to transactive memory systems among the team members within the T-ICU when telemedicine is present.

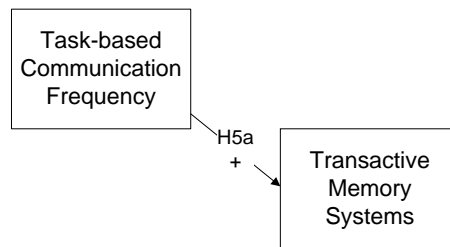


Figure 7. Hypothesis 5a

H5b: Task-based communication frequency will partially mediate the effect of telemedicine on transactive memory systems such that higher task-based communication frequency will lead to higher transactive memory systems when telemedicine is present.

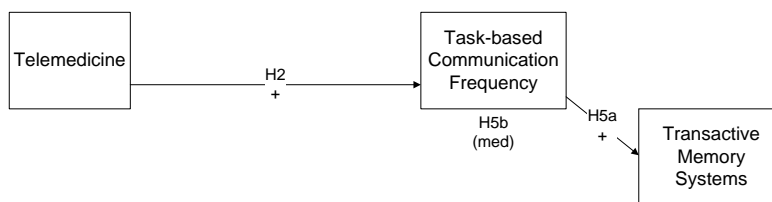


Figure 8. Hypothesis 5b

Team Outcomes

Team's interdependent interactions produce by-products – team outcomes (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). Although the inputs and processes have been well established within the team research, team outcomes are less understood primarily

because they remain poorly defined and specified (Mathieu, Maynard, Rapp, & Gilson, 2008). This poor clarification is a result of the prevalence of teams; that is, teams operate within a determined set of parameters and contexts, and they perform a specified set of tasks. Thus, performance-related outcomes are typically context specific and idiosyncratic (e.g., productive output or customer satisfaction; Gibson, Zellmer-Bruhn, & Schwab, 2003). Some researchers propose that the most descriptive and valuable outcomes are measured according to their distinct components (e.g., timeliness and quality) as opposed to an overarching global assessment (Mathieu et al., 2008). Even though utilizing such specific criteria can be insightful, such metrics suffer on generalizability and make comparisons across teams and domains difficult (Gibson et al., 2003). Consequently, leveraging blended composite measures (i.e., team effectiveness) can be valuable assets for evaluating teams in that they are comprised of various constituents, which fosters diagnosticity (Mathieu et al., 2008). Meanwhile, these composite measures are not context-specific; therefore, they are generalizable across domains, facilitating performance comparisons.

Team Effectiveness

One blended composite measure of team performance is team effectiveness. Some scholars use the terms team performance and team effectiveness interchangeably (e.g., Lepine, Piccolo, Jackson, Mathieu, & Saul, 2008), and others have combined the terms to create team performance effectiveness (Cohen, Ledford, & Spreitzer, 1996). However, Salas et al. (2009) articulate a subtle distinction and define team effectiveness as the evaluation of team performance outcomes in relation to a specified set of objective or subjective criteria. For

example, team effectiveness is often classified into performance outputs of quality and quantity, member attitudes, or behavioral outcomes (Cohen & Bailey, 1997). Cohen and Bailey (1997) further posit that facets within the task, environment, and the team all impact team effectiveness.

One particularly noteworthy factor within the team that can modify team effectiveness, especially the quality component, is communication. Indeed, a meta-analysis synthesized 72 studies and provided more definitive evidence to the criticality of information sharing (i.e., communication) for effective team outcomes (Mesmer-Magnus & DeChurch, 2009). Even within the medical context, literature indicates that communication is one of the key defining features of successful teams. For example, in a study conducted by Mazzocco et al., (2009), less frequent information sharing was associated with poor outcomes (i.e., patient complications and mortality). Frequent communication is particularly important as it provides current updates on a dynamic situation; therefore, each team member has the requisite information to accomplish the desired objectives (Sims & Salas, 2007). Additionally, because patient care is complex and evolving, frequent communication provides a means to integrate new information and new perspectives (Hoegl & Gemuenden, 2001). Moreover, frequent communication provides ample opportunities to raise questions, concerns, and evaluate information (Hoegl & Gemuenden, 2001) as well as anticipate the needs of others (Salas et al., 2005). Finally, effective communication fosters the ability to assure that the entire team has shared goals, expectations, situation awareness, and plan execution (Salas, Rosen, Burke, & Goodwin, 2009). Ultimately, teams must attain information about the surroundings and task, and this information must be distributed to all of the team members to perform accordingly (MacMillan, Entin, & Serfaty, 2004). Without

communication, ideas may go unconsidered and information can become outdated, inaccurate, or incomplete, which results in subpar teamwork quality.

H6: More task-based communication frequency among the team members within the T-ICU will lead to better quality of team effectiveness when telemedicine is present.

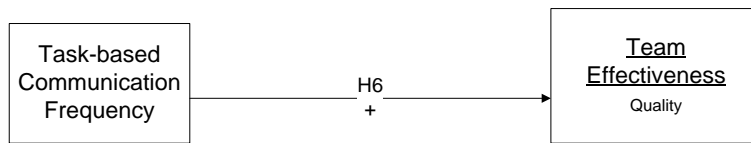


Figure 9. Hypothesis 6

Another element within the team that can possibly influence team effectiveness is the team's transactive memory system. Indeed, well developed TMSs have been repeatedly associated with improvements in team effectiveness (Austin, 2003; Michinov & Michinov, 2009; Zhang, Hempel, Han, & Tjosvold, 2007). Such effectiveness enhancements can be attributable to the variety of advantages inherent with TMSs. One benefit is that they allow individuals to obtain thorough, deep, and specialized expertise without the burden of storing other, related information (Peltokorpi, 2008). This ties into the second advantage in that they afford for a complex and robust repository of stored information since this knowledge is distributed amongst the team (Hollingshead, 1998; Ren & Argote, 2011; Wegner, 1986). Essentially, team members are responsible for less information individually, but the team collectively has access to a larger, more comprehensive knowledge base (Jackson & Moreland, 2009). Such advantages are essentially capable since transactive memory systems are analogous to external memory aids (Wegner, 1986). Utilizing various team members not only circumvents any limitation or capacity constraints within leveraging only an individual cognition, but it also enhances the information

processing capability of the team (Peltokorpi, 2008). Ultimately, each team member being responsible for less but specialized information reduces each member's respective cognitive workload (Peltokorpi & Manka, 2008). Finally, other perks to transactive memory systems include better planning and problem solving by knowing the most appropriate team member to assign and execute tasks efficiently (Lewis, 2004; Moreland, 1999). Having a clear understanding of team member's expertise requires less time to search for the information thereby facilitating efficient planning and problem solving (Peltokorpi & Manka, 2008). In addition, understanding the team's respective expertise helps to align problems with the individual who possesses the appropriate knowledge and skill (Moreland & Levine, 1992). Moreover, team members are also more capable of executing tasks more efficiently by anticipating rather than reacting (Moreland, 1999). Subsequently, I hypothesize the following:

H7a: Stronger transactive memory systems among the team members within the T-ICU will lead to better timeliness of team effectiveness when telemedicine is present.

H7b: Stronger transactive memory systems among the team members within the T-ICU will lead to better quality of team effectiveness when telemedicine is present.

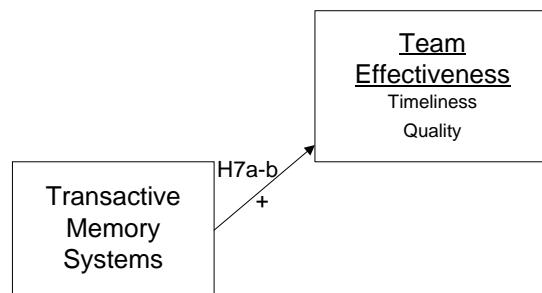


Figure 10. Hypotheses 7a-b

Climate/Conditions

As expected, the climate and conditions in which a team performs substantially impact team behaviors, attitudes, and cognitions. Simply co-locating team members or providing a means to engage in teamwork processes, such as distributed communication (i.e., telemedicine) does not guarantee that appropriate teamwork will ensue. Despite the abundant amount of research demonstrating the necessity of effective teamwork skills for successful team performance (Leggat, 2007; Mathieu & Rapp, 2009) as well as a practically universal understanding that teamwork skills are paramount, they do not always manifest particularly in the medical field.

Within any team context, the surrounding conditions may impact team members physically or psychologically. However, the practicality of altering such conditions to enhance teamwork can become a problematic issue. For instance, some of the conditions within the medical field, such as high-stakes and time-pressure, are inherent within the task of patient care; therefore, the current study will focus on the modifiable psychological conditions, and more specifically psychological safety. Although it is plausible that psychological safety would impact team attitudes and cognitions, it is arguably the most impactful for communication especially within the medical domain.

Psychological Safety

Unsurprisingly, medical practice does not always promote a psychologically safe environment. Psychological safety is a shared sense amongst the team that it is safe to take interpersonal risks (Edmondson, 1999). Psychologically safe environments are characterized by

employees possessing a willingness to take risks by asking for assistance when necessary or admitting mistakes when applicable and by organizations that establish policies and procedures to encourage open and supportive interactions (Baer & Frese, 2003; West, 1990). It should be noted though that this sense of sharedness or safety does not imply close friendships or the absence of problems (Edmondson, 2004). Psychological safety is simply that people feel confident that they will not suffer any consequences, such as others will not embarrass or ridicule them for speaking up, acknowledging oversights, and seeking help (Edmondson, 1999; May, Gilson, & Harter, 2004). In essence, team members feel that the gain in speaking up is worth the cost (Edmondson, 2004).

Team members generate a collective sense of psychological safety from norms along with the shared experiences (Edmondson, 1999). Norms within an organizational context guide behavior, attitudes, and beliefs at work (Hochschild, 1983), and frequently, the established norms within the workplace put emphasis on preserving one's image by not admitting to gaps in knowledge, committing errors, or requiring the assistance of others. In other words, the hesitancy to engage in the aforementioned risk taking behaviors is a result of the expected norms that propagate a sense that people value their image and prefer to "save face" (Brown, 1990). People adhere to these informal rules (i.e., norms) to refrain from being isolated, which as social beings is undesirable. Simply stated, people feel unsafe when they are disconnected (Kahn, 1990).

In addition to a sense of preserving one's image, low self-efficacy also hinders speaking up; that is, hesitancy to contribute and to communicate openly is also commonplace because individual team members may have low levels of self-efficacy (i.e., a belief in oneself to

accomplish a task; Bandura, 1993). Having confidence that others will support and respect a team member's contributions foster open communication because that team member will feel that his/her contributions are valued (Tyler & Lind, 1992). When individuals feel that their additions are worthwhile and appreciated, they find their work more meaningful and satisfactory (Kahn, 1990). For example, supportive and encouraging responses to questions will foster team members to form the belief that the climate is psychologically safe (Edmondson, 1996; May et al., 2004). In other words, if team members solicit feedback, it is an indication that ideas are heard and respected, which is likely to normalize or even enhance active participation (Edmondson, 2004). Active participation and open information exchange necessitates a safe environment throughout the team and organization (E Salas, Wilson, et al., 2008). Said differently, psychological experience and climate propels and provokes behavior (Hackman & Oldham, 1976; Kahn, 1990).

A sense of self-efficacy and the organizational norms contribute to a climate generically; however, there are two highly influential and commonplace elements that contribute to decrements in psychological safety within the medical field specifically. The first pertains to the tangible consequences that could arise from potentially calamitous actions (Edmondson, 1999). As a result, medical practice continues to concentrate on individuals as opposed to a system's perspective when analyzing and understanding adverse events (Leape et al., 2009). Sustaining an individual "blame game", unfortunately, deters people from openly communicating for fear of negative consequences (Nembhard & Edmondson, 2006).

The second is that the norms within the field promote prevalent status differences between physicians and nurses or ancillary care providers (Leape et al., 2009). These pervasive hierarchical differences make communicating more challenging and potentially less common, particularly for lower status individuals (Edmondson, 2003). The hierarchical and status literature proposes that individuals of lower status are more likely to conceal information (Argyris, 1985) and less likely to openly communicate because they devalue their contributions to the task (Pagliari & Grimshaw, 2002). Indeed, one study demonstrated that even if nurses witness or encounter a problem and generate a solution to resolve the issue, they generally do not communicate this to more hierarchical individuals (Tucker & Edmondson, 2003). Research pertaining to organizational silence indicates that fears related to risk are paramount for an employee's willingness to communicate openly (Detert & Edmondson, 2005). In fact, lower status individuals feel more vulnerable (Miller, 1976); thus, to abstain from committing any errors or embarrassment, team members will remain silent and withhold information, regardless of its importance (Edmondson, 2003). However, if team members make a concerted effort to exhibit inclusiveness, others are more likely to feel supported, important, and valuable to the task (Nembhard & Edmondson, 2006). Similarly, familiarity, which can be established through repeated interactions, also positively influences shared experiences and exchanging information (Edmondson, 2003) and negatively influences concealing information (Edmondson, 1999). Clearly, the psychological conditions established at work significantly influence behavior (Kahn, 1990). Therefore, the combination of research that indicates supportive structures and shared

beliefs (i.e., psych safety) will influence team dynamics (i.e., attendance and communication) provides grounds to hypothesize the following:

H8: Psychological safety will moderate the relationship between telemedicine and attendance, such that, when psychological safety is high, there will be more attendance during the rounds in the telemedicine group.

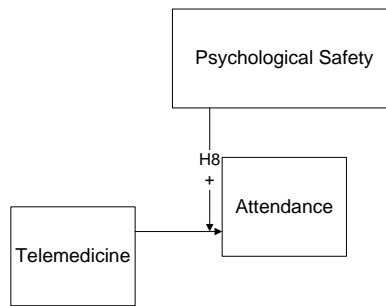


Figure 11. Hypothesis 8

H9: Psychological safety will moderate the relationship between telemedicine and task-based communication frequency, such that, when psychological safety is high, there will be a higher rate of communication among the team members during rounds in the telemedicine group.

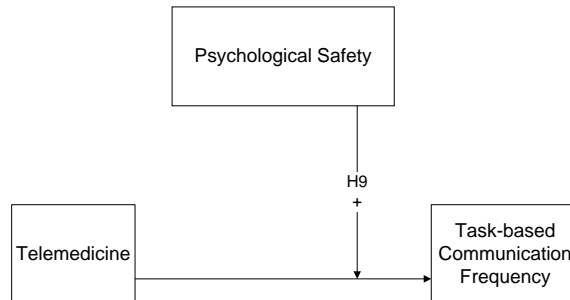


Figure 12. Hypothesis 9

To summarize the above review, I expect that telemedicine will positively influence attendance and communication; however, those relationships will be moderated by psychological safety. Communication, in turn, will positively impact transactive memory systems, trust, and team effectiveness. Additionally, transactive memory systems will also affect team effectiveness. For a pictorial depiction of these relationships, refer to Figure 1. In addition, refer to Table 3 for a summary of the study hypotheses, and refer to Table 4 for a summary of the study variables.

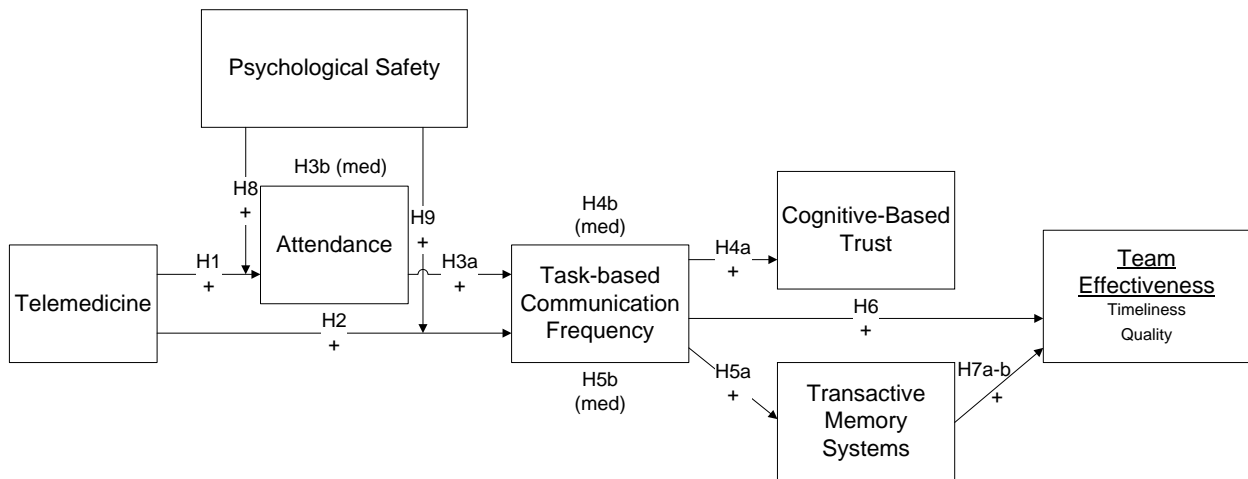


Figure 13. Hypothesized Relationships between Study Variables

Table 3. *List of original hypotheses*

H1:	Telemedicine will lead to more clinicians attending rounds within the T-ICU
H2:	Telemedicine will lead to a greater task-based communication frequency among the team members during rounds within the T-ICU.
H3a:	Attendance among the team members during rounds will be positively related to task-based communication frequency among team members within the T-ICU.
H3b:	Attendance will partially mediate the effect of telemedicine on task-based communication frequency such that attendance will increase task-based communication frequency when telemedicine is present.
H4a:	Task-based communication frequency will be positively related to cognitive-based trust among the team members within the T-ICU.
H4b:	Task-based communication frequency will partially mediate the effect of telemedicine on cognitive-based trust such that higher task-based communication frequency will lead to higher cognitive-based trust when telemedicine is present.
H5a:	More task-based communication frequency among the team members will positively lead to transactive memory systems among the team members within the T-ICU when telemedicine is present.
H5b:	Task-based communication frequency will partially mediate the effect of telemedicine on transactive memory systems such that higher task-based communication frequency will lead to higher transactive memory systems when telemedicine is present.
H6:	More task-based communication frequency among the team members within the T-ICU will lead to better quality of team effectiveness when telemedicine is present.
H7a:	Stronger transactive memory systems among the team members within the T-ICU will lead to better timeliness of team effectiveness when telemedicine is present.
H7b:	Stronger transactive memory systems among the team members within the T-ICU will lead to better quality of team effectiveness when telemedicine is present.
H8:	Psychological safety will moderate the relationship between telemedicine and attendance, such that when psychological safety is high, there will be more attendance among the team members during rounds the in telemedicine group.
H9:	Psychological safety will moderate the relationship between telemedicine and task-based communication frequency, such that when psychological safety is high, there will be more task-based communication frequency among the team members during rounds the in telemedicine group.

Table 4. *Summary of Study Constructs and Metrics*

Construct	Variable Type	Definition	Scale Used	Items	Sample Items
<i>Telemedicine</i>	Independent	Providing patient care utilizing electronic and telecommunication technologies when participants are separated by a distance	N/A	N/A	N/A
<i>Team Psychological Safety</i>	Moderator	A shared sense amongst the team that it is safe to take interpersonal risks	(Edmondson, 1999) 1 (Never) to 7 (Always)	7	“Working with members of this team, my unique skills and talents are valued and utilized.”
<i>Attendance</i>	Mediator	The number of clinicians present during rounds	N/A	N/A	N/A
<i>Communication</i>	Mediator	The amount of information exchanged between a sender and a receiver	(Hoegl & Gemuenden, 2001) 1 (Strongly Disagree) to 7 (Strongly Agree)	10	“There was frequent communication within the team.”
			Total number of different meaningful task-based utterances	N/A	N/A
<i>Transactive Memory System</i>	Mediator	The shared division of cognitive labor with respect to encoding, storage, and retrieval of information	(Austin, 2003) 1 (Very Low Ability) to 7 (Very strong ability)	8	Knowledge of patient background (e.g., past/history)
			Lewis (2003) 1 (Strongly Disagree) to 7 (Strongly Agree)	15	“Different team members are responsible for expertise in different areas”

Construct	Variable Type	Definition	Scale Used	Items	Sample Items
<i>Cognitive-Based Trust</i>	Dependent	A psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another	(Wildman et al., 2009) 1 (Not at All) to 6 (Very Much So)	4	“To what extent do you feel assured that the other department will make intelligent decisions?”
<i>Team Effectiveness</i>	Dependent	The evaluation of team performance outcomes in relation to a specified set of objective or subjective criteria	(Gibson et al., 2003) 1 (Strongly Disagree) to 7 (Strongly Agree)	11	“This team is slow.” “This team has a low error rate.”

CHAPTER THREE: MATERIALS AND METHODS

Participants

Participants were clinicians over the age of 18 who had direct patient contact within the Trauma Intensive Care Unit (T-ICU) at a large Southeastern hospital in the United States. Participation was voluntary, and clinicians received a \$25 gift certificate as compensation. Sixteen clinicians completed surveys across all three time periods, with 32 clinicians completing the first survey and 26 clinicians completing the second survey. Of those 32 clinicians, there were 18 nurses, 5 attending physicians, 4 residents, 4 fellows, and 1 nurse practitioner. Additionally, there were 16 males and 16 females. The participant's ages ranged from 24 to 56 years, ($M = 37.87$, $SD = 9.14$). Their years of experience in their current role ranged from less than 1 year to 30 years ($M = 8.22$, $SD = 9.33$). The ethnicities of the sample include Caucasian (43.8%), Black (6.3%), Hispanic (37.5%), and Asian (12.5%). Fourteen clinicians reported working during the day shifts, and 5 clinicians reported working the night shifts. Thirteen clinicians reported working both shifts. Twenty eight participants reported working both weekdays and weekends. Meanwhile, a mere 2 participants reported working weekdays exclusively, and 2 participants reported working weekends exclusively. The participant's typically weekly working hours ranged from 24 hours to 90 hours, ($M = 53$, $SD = 20.60$). Furthermore, 11 people disclosed being "on call" staff, and 21 people did not indicate being "on call" staff.

Thirty four rounds were recorded over a 60 day period with 24 rounds not utilizing telemedicine and 10 rounds utilizing telemedicine. Seventeen of the recordings were rounds

where telemedicine was unavailable, therefore, not used. Seven of the recordings were rounds that did have telemedicine available; however, the clinicians elected not to use telemedicine. Ten of the recordings were rounds where telemedicine was available and used.

Design

This field study was a mixed model design with the between groups factor (between treatment and control) and the within groups factor (pre- and post-intervention). Both groups provided patient care within the same unit (i.e., ICU). Most of the clinicians, though, were static members within the unit (i.e., attending physicians, nurses, and other ancillary staff), meaning they remained on the unit continuously and did not rotate out of the unit. Conversely, a few clinicians within the unit were more dynamic, namely residents and fellows. Residents and fellows were typically on the unit for thirty day rotations. Both static and dynamic members were eligible to be in the control and experimental groups. However, no dynamic clinicians elected to be in the study during the intervention period. The control group conducted rounds in the same remote room (as the experimental group) without the telemedical information. Following a thirty day period, the experimental group conducted rounds in the remote room while utilizing telemedicine for one month. Simply stated, when telemedicine was being used to conduct rounds, that served as the experimental group, and when telemedicine was not being used to conduct rounds, that served as the control group.

The control group conducted rounds away from the patients' bedside and in a room separate from the unit. This group had access to patient's x-rays on one large monitor, laboratory results on another large monitor, and paper-based patient files. This group did not have access to

telemedicine. After the control period, the experimental group conducted rounds in the same remote room as the control group, which also fostered consistency and reduced potential confounds, such as room layout and monitor size. See Figure 2 for a picture of the room in which rounds were conducted. Similar to the control group, the experimental group had access to patient x-rays on the large monitor, laboratory results on another large monitor, and paper-based files; however, this group also had access to the information provided by the RP-7 Robot. The RP-7 robot was a mobile device that was controlled in the remote room and was maneuvered throughout the unit accordingly. The RP-7 robot projected a live visual feed directly from the unit to a third large monitor in the remote room. In addition to visual information, there was a phone on the mobile device that facilitated real-time, verbal communication between individuals on the unit and those in the remote room. RP-7 was also equipped with speakers, so that individual(s) in the remote room could verbally communicate with staff and/or patients in real time. The remote room also was outfitted with speakers, so all personnel within the room were capable of hearing real-time, auditory information from the unit. Refer to Figure 3 for a pictorial of the robot.



Figure 14. Picture of the remote rounding room



Figure 15. Picture of the RP-7 (Telerounding Robot)

Procedure

All of the static staff provided consent and completed pre-intervention measures online at the onset of the study (pre-control period), after the control period (post-control period), and following a sustained presence of telemedicine (post-experimental period). Meanwhile, the other dynamic team members completed the informed consent and measures at the onset of their 30 day rotations and at the end of their 30 day rotation. Refer to Figure 4 for a timeline of the procedure.

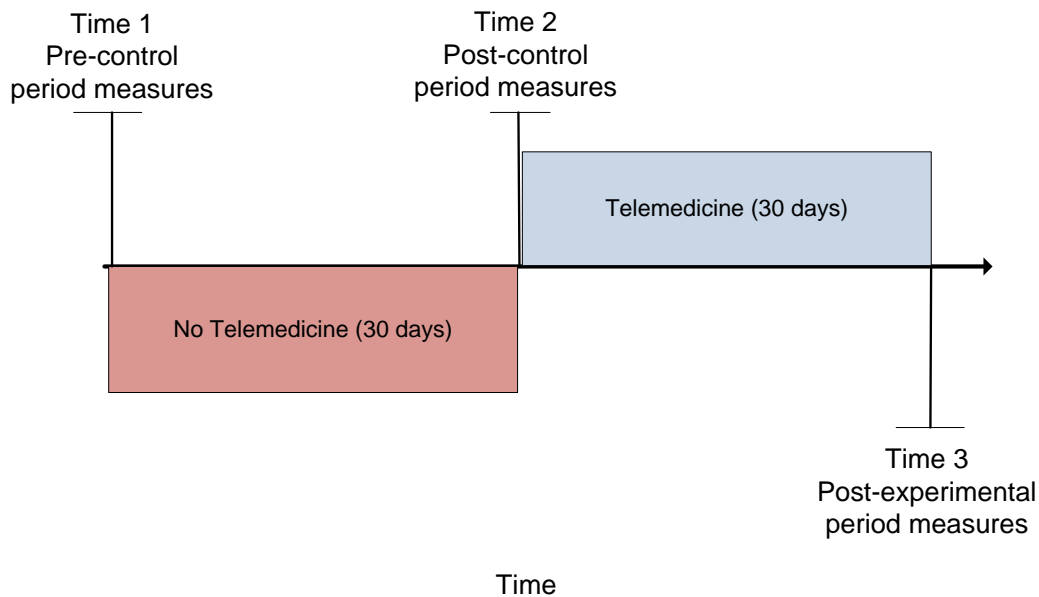


Figure 16. Timeline of study

Measures

To better understand the impact of utilizing telemedicine on team-based attitudes, behaviors, and cognitions while conduct rounds within the Trauma-Intensive Care Unit, several metrics were collected throughout the study period. All self-report measures were administered

and completed online using Qualtrics. Unless otherwise noted, all surveys included Likert-type scales with responses ranging from 1 (Strongly Disagree) to 7 (Strongly Agree).

Demographic information. The demographic survey targeted general background information (e.g., age and gender) as well as role and clinical experience. This questionnaire consisted of multiple choice items and open-ended questions, which obtain a thorough and accurate representation of the clinicians. Obtaining background information was critical since a clinician's experiences could have heavily influence attitudes and behaviors. See Appendix A for the full scale.

Psychological Safety. Psychological safety was assessed by adapting a scale created by Edmonson (1999). This measure included 6 Likert-type questions with response options ranging from 1 (never) to 7 (always). Sample items included "If you make a mistake on this team, it is often held against you" and "It is safe to take a risk on this team". See Appendix B for the full scale.

Communication. Communication was measured via video observations and a communication coding scheme. Communication was unitized based upon the smallest semantic meaning, and all semantic utterances were classified as either task-based (i.e., communication relevant to the task at hand) and nontask-based (i.e., communication extraneous to the task). In other words, communication frequency was the total amount of novel task-based semantic meanings. Perceptions of communication were also measured utilizing the communication sub-dimension of the teamwork quality scale created by Hoegl and Gemuenden (2001). An example

of a sample item was, “There was frequent communication within the team”. See Appendix C for the full scale.

Transactive Memory: Transactive memory was measured using two metrics. The first metric was developed by Austin (2003), and it tapped into the transactive memory system itself. The metric consisted of two parts with the first component designed to identify which individuals were associated with each skill. The second part of the metric consisted of a self-report, where individuals rated their ability to perform each specified skill on a Likert scale from 1 (very low ability) to 7 (very high ability). The next metric of transactive memory was developed by Lewis (2003), and it focused on an individual’s appraisal of the perceptions of the transactive memory system. See Appendix D and E for the full scales.

Trust: Trust was evaluated by using the 4 items that tap into cognitive-based trust from a survey developed by Wildman et al., (2009), and responses were based from 1 (not at all) to 6 (very much so). A sample item of the measure included “Assured the other team members will make intelligent decisions”. See Appendix F for the full scale.

Team Effectiveness: Team effectiveness was evaluated by leveraging the sub-dimensions timelines and quality from the Team Outcome Effectiveness measure developed by Gibson et al. (2003). Sample items from the timelines subcomponent included, “This team wastes time” and “This team is slow”. Meanwhile, sample items from the quality subcomponent included, “This team is consistently error free” and “This team does high quality work”. See Appendix G for the full scale.

Attendance: Attendance was measured by totaling the number of clinicians who were present during rounds over the course of the entire control period and again for the experimental period.

CHAPTER FOUR: RESULTS

All of the analyses for this study were conducted using PASW/SPSS 20.0 for Windows. As specified in the method, the metrics consisted of surveys completed by the participants as well as video recordings from the rounds. Due to practical and logistical constraints, such as participants specifically requesting “off-camera” zones (i.e., a location in the room that was out of the view of the camera), the difficulty in identifying individuals in the recording, and the ability to use a participant identification code for the surveys that ensured anonymity, connecting the behavior data to the survey data was not feasible. Therefore, all of the behavioral data were analyzed separately from the survey data. Consequently, the original model has been adjusted to reflect this separation, with pink coloring referring to behavioral data and blue coloring referring to survey data. See Figure 17 for the adjusted model.

For the coefficient alpha reliabilities of the surveys, refer to Table 5. It should be noted that reliability coefficients were calculated using the surveys at time 1 since that period had the largest sample size. The descriptive statistics and Pearson product-moment correlations of the behavioral data is reported in Table 6, and the descriptive statistics and Pearson product-moment correlations of the survey data is reported in Tables 7-10.

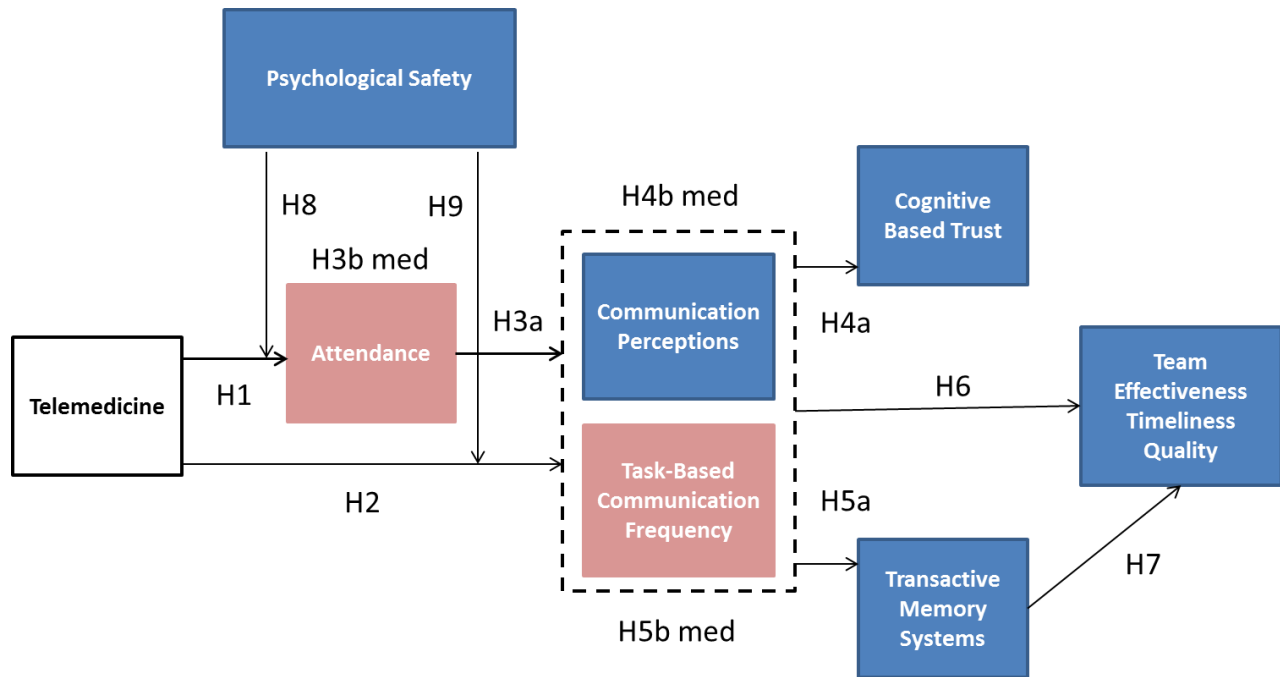


Figure 17. Modified hypothesized relationship model

Table 5. Cronbach's Alpha reliabilities.

Measure	Cronbach's Alpha reliability coefficient
Team Psychology Safety (T1)	.82
Communication Perceptions (T1)	.81
Trust (T1)	.95
Transactive Memory Systems (T1)	.87
Team Effectiveness – Timeliness (T1)	.93
Team Effectiveness – Quality (T1)	.89

Table 6. Summary of Intercorrelations, Means, and Standard Deviations of Behavioral Data.

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Telemedicine (Presence/Absence)	1										
2. Attendance	.49**	1									
3. Task-based Communication Density	.34	.19	1								
4. Task-based Question Frequency	.19	-.05	.55**	1							
5. Exits (of staff from remote rounding room)	.00	-.03	-.04	.11	1						
6. Entrances (of staff from remote rounding room)	-.02	-.02	-.15	.07	.93**	1					
7. Interruptions	-.29	.12	-.36*	-.18	.42*	.51**	1				
8. Number of Patients Discussed	.29	.40*	-.13	-.32	.19	.21	.30	1			
9. Duration of Each Patient Discussion (minutes)	-.38*	-.04	-.29	-.04	.30	.40*	.46**	-.06	1		
10. Length of round (minutes)	-.16	.19	-.35*	-.25	.38*	.51**	.62**	*.58**	.77**	1	
11. Frequency of mentions of insufficient time	-.24.	.31	-.17	-.07	.06	.08	.21	-.04	.35*	.24	1
<i>M</i>	.29	10.97	208.68	25.71	7.59	7.50	3.76	12.32	7.44	91.34	.12
<i>SD</i>	.45	4.28	33.82	9.35	6.15	5.73	2.63	3.10	2.17	33.07	.33

Note. N = 34 *p < .05, two tailed, **p < .01, two tailed

Table 7. Summary of Time 1 Intercorrelations, Means, and Standard Deviations of Survey Data.

Variable	1	2	3	4	5	6
1. Team Psychological Safety T1	1					
2. Communication Perceptions T1	.58**	1				
3. Cognitive-based Trust T1	.37	.60**	1			
4. Transactive Memory Systems T1	.52**	.63**	.56**	1		
5. Team Effectiveness – Timeliness T1	.43*	.73**	.79	.68**	1	
6. Team Effectiveness – Quality T1	.51**	.78**	.79**	.73**	.87**	1
<i>M</i>	5.15	5.31	5.36	5.13	5.44	4.97
<i>SD</i>	1.01	.84	1.30	.87	1.22	1.21

Note. N = 32 *p < .05, two tailed, **p<.01, two tailed

Table 8. Summary of Time 2 Intercorrelations, Means, and Standard Deviations of Survey Data.

Variable	1	2	3	4	5	6
1. Team Psychological Safety T2	1					
2. Communication Perceptions T2	.65**	1				
3. Cognitive-based Trust T2	.53**	.60**	1			
4. Transactive Memory Systems T2	.38*	.63**		1		
5. Team Effectiveness – Timeliness T2	.64**	.73**	.79**	.68**	1	
6. Team Effectiveness – Quality T2	.57**	.78**	.79**	.73**	.87**	1
<i>M</i>	5.33	5.36	5.46	5.30	5.54	4.96
<i>SD</i>	.97	.88	1.31	.69	1.04	.98

Note. N = 26 *p < .05, two tailed, **p<.01, two tailed

Table 9. Summary of Time 3 Intercorrelations, Means, and Standard Deviations of Survey Data.

Variable	1	2	3	4	5	6
1. Team Psychological Safety T3	.78**	.60*	.39	.42	.33	.34
2. Communication Perceptions T3	.68**	.65**	.24	.45	.36	.36
3. Cognitive-based Trust T3	.47	.66**	.61*	.63**	.69**	.70**
4. Transactive Memory Systems T3	.57*	.60**	.22	.56*	.44	.44
5. Team Effectiveness – Timeliness T3	.49	.47	.03	.50	.41	.27
6. Team Effectiveness – Quality T3	.53*	.66**	.45	.70**	.72**	.76**
<i>M</i>	5.63	5.40	5.84	5.51	5.73	5.22
<i>SD</i>	.80	.83	.77	.78	.86	.91

Note. N = 16 *p < .05, two tailed, **p < .01, two tailed

Table 10. Summary of Difference Score Intercorrelations, Means, and Standard Deviations of Survey Data.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Team Psychological Safety Month 1 (T1-T2)	1											
2. Communication Perceptions Month 1 (T1-T2)	.26	1										
3. Cognitive-based Trust Month 1 (T1-T2)	.32	-.32	1									
4. Transactive Memory Systems Month 1 (T1-T2)	.33	.14	.38	1								
5. Team Effectiveness – Timeliness Month 1 (T1-T2)	.54**	.34	.21	.57**	1							
6. Team Effectiveness – Quality Month 1 (T1-T2)	.45**	.37	.20	.60**	.83**	1						
7. Team Psychological Safety Month 2 (T2-T3)	-.77**	.07	-.55*	-.26	-.35	-.34	1					
8. Communication Perceptions Month 2 (T2-T3)	.04	-.48	.23	-.20	-.41	-.45	-.16	1				
9. Cognitive-based Trust Month 2 (T2-T3)	-.20	.53*	-.87**	-.06	.28	.15	.43	-.15	1			
10. Transactive Memory Systems Month 2 (T2-T3)	.20	-.43	.14	-.39	-.17	-.37	-.40	*.51	-.13	1		
11. Team Effectiveness – Timeliness Month 2 (T2-T3)	.10	-.48	.48	-.18	-.30	-.42	.09	.58*	-.29	.15	1	
12. Team Effectiveness – Quality Month 2 (T2-T3)	.10	-.48	.48	-.18	-.30	-.42	.09	.58*	-.29	.15	1.00**	1
<i>M</i>	-.22	.42	-.22	-.05	-.10	-.56	-.21	-.13	-.44	-.59	-.11	-.11
<i>SD</i>	.85	.74	1.58	.81	1.01	1.16	.63	.66	1.58	1.13	.74	.74

Note. N = 26 (Month1), N = 16 (Month 2)*p < .05, two tailed, **p<.01, two tailed

Behavioral Data Results

Observers viewed the 34 daily round recordings and calculated attendance, the number of patients discussed, the duration of each patient discussion, entrances and exits from the rounding room, interruptions, and explicit references to running out of time for patient discussion. To determine the inter-rater reliability of the raters, I calculated the Pearson correlation between two raters for one of the recordings. The categories within this inter-rater reliability include the number of people attending, speaking turns, exits from the room, entrances from the room, interruptions, patients discussed, explicit mentions of lack of time. Typically, an acceptable levels for such calculation is .8 or higher, and in this instance, raters demonstrated 100% (correlation = 1.00). Realizing this calculation is remarkably high, it may be inflated due to the small number of rating categories. However, the raters did have extremely high consistency.

In addition to the observational ratings, individuals also transcribed 8 minutes at approximately the 60 minute mark for each of the 34 recordings. This duration was selected because the mean for the first 15 patients discussed was approximately 8 minutes. Thus, these 8 minutes served as a representative sample of the communication for the entire round. To avoid the need for inter-rater calculations, only one person unitized and coded the transcripts to ensure there were no discrepancies in unitizing or coding between multiple individuals.

The results for attendance and communication density will be discussed within hypothesis 1 and 2 respectively; however, the remaining behavioral data will be described later under exploratory analyses. Irrespective of the behavioral category (e.g., attendance, interruptions, etc.), all data was collected and analyzed at the group level. Since the specific

analyses varied according to the relationships being tested, every test will be discussed in its respective section.

Hypothesis 1 Results

H1: Telemedicine will be positively related to clinicians attending rounds within the T-ICU.

To test the effect of telemedicine on clinician attendance, I conducted a one-way between-groups of analysis of variance, which included three groups – rounds without telemedicine available, rounds with telemedicine available but it was not used, and rounds with telemedicine available and used. There was a significant difference in attendance between rounds for the various groups: $F(2, 31) = 7.76, p < .01, \eta^2 = .33$. Post hoc comparisons using LSD revealed that attendance was significantly greater for rounds with telemedicine ($M = 14.20, SD = 4.63$) compared to rounds without telemedicine available nor used ($M = 10.59, SD = 3.45$) and rounds with telemedicine available but not used ($M = 7.29, SD = 1.80$). Regardless of its availability, rounds conducted without telemedicine did not significantly differ. Thus, the data support H1.

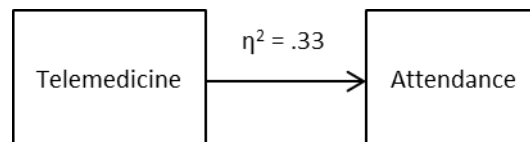


Figure 18. Hypothesis 1 findings with telemedicine

Modified Hypothesis 2 Results

H2: Telemedicine will lead to a greater task-based communication density among the team members during rounds within the T-ICU.

To identify the effect of telemedicine on task-based communication density among the team during rounds, I conducted an independent-samples t-test between rounds where telemedicine was not available nor used and rounds where telemedicine was available and used. There were significant differences in task-based communication density (as measured by the smallest semantic unit) between rounds with no telemedicine available nor used, ($M = 202.88$, $SD = 30.30$) and rounds with telemedicine available and used, $M = 226.00$, $SD = 37.25$, $t(25) = -1.76$, $p = .05$, mean difference = -23.12 , 95% CI: -50.18 to 3.94 (eta squared = $.11$). The findings support this hypothesis; therefore, H2 is supported.

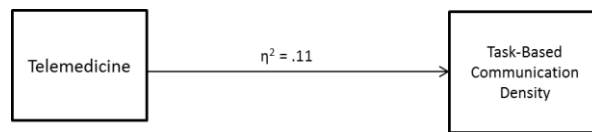


Figure 19. Hypothesis 2 findings with telemedicine

Hypothesis 3a Results

H3a: Attendance among the team members during rounds within the T-ICU will be positively related to task-based communication density among the team members within the T-ICU.

To test the effect of attendance on task-based communication density, task-based communication density was regressed onto attendance. Attendance had no predictive value effect on task-based communication density among team members during rounds, ($R^2 = .04$, Adjusted $R^2 = .01$, $F(1, 32) = 1.18$, $p = .29$).

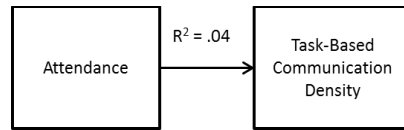


Figure 20. Hypothesis 3a findings with telemedicine

Hypothesis 3b Results

H3b: Attendance will partially mediate the effect of telemedicine on task-based communication density such that attendance will increase task-based communication density when telemedicine is present.

In order to test for mediation utilizing the Baron and Kenny methodology, the direct relationships must be significant. However, H3a was not significant; therefore, I could not test H3b.

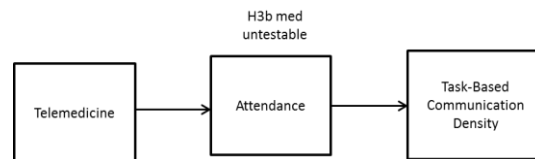


Figure 21. Hypothesis 3b findings

Survey Data Results

To identify any differences between the constructs from T1 and T2, I conducted a paired-samples t-test. There were no significant differences in any of the constructs (i.e., psychological safety, communication perceptions, cognitive-based trust, transactive memory systems, and team effectiveness). In addition, I also conducted a paired-samples t-test to detect any differences in the constructs between T2 and T3. Again, there were no significant differences between any of the variables (i.e., psychological safety, communication perceptions, cognitive-based trust, transactive memory systems, and team effectiveness) at T2 and T3. Finally, I also conducted an

independent-samples t-test to identify any differences in psychological safety, communication perceptions, cognitive-based trust, transactive memory systems, and team effectiveness between the individuals who completed all three surveys and those who did not. The results of this analysis also indicated that there are no significant differences in the individuals who only completed a portion of the surveys and those who completed all of the surveys.

To determine the impact of the period when telemedicine was removed (i.e., month 1) compared to the period when telemedicine was available (i.e., month 2), all primary analyses were conducted with difference scores where ($\text{Month}_1 = T1 - T2$) and ($\text{Month}_2 = T2 - T3$). Thus, a negative score indicates the mean of that score actually increased, and a positive score indicates the mean of that score actually decreased. Additionally, as suggested earlier, all of the survey data were collected at the individual level. Although it is less than ideal to use surveys to capture behaviors, the remaining hypotheses were analyzed utilizing perceptions of communication, where applicable. As a final note, I employed the transactive memory systems metric developed by Lewis (2003) for all germane analyses due to substantial differences in sample size from the transactive memory systems measure developed by Austin (2003). To illustrate, only 3 participants completed the measure created by Austin successfully at time 3.

Modified Hypothesis 4a Results

H4a: A change in communication perceptions among the team members within the T-ICU will be positively related to a change in cognitive-based trust among the team members within the T-ICU under the conditions of telemedicine.

I conducted two regression analyses to test the effect of a change in communication perceptions among team members on a change in cognitive-based trust when telemedicine was available and unavailable. The effect was non-significant for both conditions. When telemedicine was unavailable, there was no predictive value of a change in communication perceptions among team members on a change in cognitive-based trust ($R^2 = .10$, Adjusted $R^2 = .06$, $F(1,23) = 2.59$, $p = .12$). Similarly, when telemedicine was available, the variables still appeared to have no relationship ($R^2 = .02$, Adjusted $R^2 = -.05$, $F(1, 14) = 2.63$, $p = .58$). Therefore, H4a was not supported by these data.

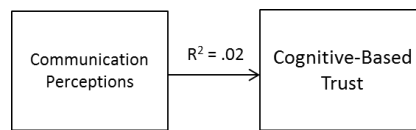


Figure 22. Hypothesis 4a findings with telemedicine

Modified Hypothesis 4b Results

H4b: A change in communication perceptions will partially mediate the effect of telemedicine on a change in cognitive-based trust such that a change in communication perceptions will be positively related to a change in cognitive-based trust under the conditions of telemedicine.

As stated previously, the Baron and Kenny mediation methodology stipulates that the direct relationships must be significant. However, because the relationship between telemedicine and communication perceptions and H4a were non-significant, it was not appropriate to test for mediation. Consequently, I could not test H4b.

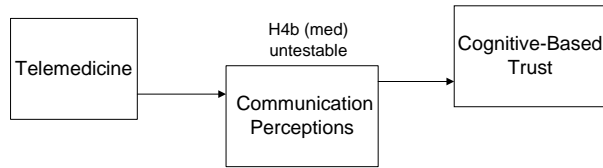


Figure 23. Hypothesis 4b findings

Modified Hypothesis 5a Results

H5a: A change in communication perceptions among the team members will be positively related to the change in transactive memory systems among the team members within the T-ICU under the conditions of telemedicine.

I utilized two regression analyses to test the effect of a change in communication perceptions among team members on a change in transactive memory systems when telemedicine was available and unavailable. During the unavailability of telemedicine, there was no predictive value of the change in communication perceptions among team members on the change in transactive memory ($R^2 = .02$, Adjusted $R^2 = -.02$, $F(1, 24) = .49$, p^{ns}). When telemedicine was available, the change in communication perceptions significantly predicted 26.2% of the variance in the change in transactive memory ($R^2 = .26$, Adjusted $R^2 = .21$, $F(1, 14) = 4.96$, $p < .05$). Thus, these data supported H5a.

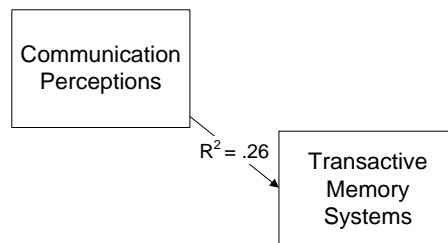


Figure 24. Hypothesis 5a findings with telemedicine

Modified Hypothesis 5b Results

H5b: A change in communication perceptions will partially mediate the effect of telemedicine on the change in transactive memory systems such that a change in communication perceptions will be positively related to a change in transactive memory systems under the conditions of telemedicine.

Similar to H4b, I could also not test H5b because the relationship between telemedicine and communication perceptions was non-significant, and the Baron and Kenny method necessitates that the direct relationships be significant.

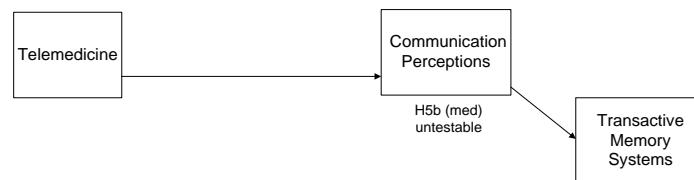


Figure 25. Hypothesis 5b findings

Modified Hypothesis 6 Results

H6: The change in communication perceptions among the team members within the T-ICU will be positively related to the change in quality of team effectiveness under the conditions of telemedicine.

I conducted two regression analyses to test the effect of a change in communication perceptions among team members on the change in the quality of team effectiveness with the availability and unavailability of telemedicine. When telemedicine was unavailable, there was a marginally significant effect of the change in communication perceptions among team members on quality of team effectiveness ($R^2 = .14$, Adjusted $R^2 = .10$, $F(1, 24) = 3.88$, $p = .06$). When telemedicine was available, a change in communication perceptions significantly predicted

33.7% of the variance in the change of quality of team effectiveness ($R^2 = .34$, Adjusted $R^2 = .29$, $F(1, 14) = 7.13$, $p < .05$). Thus, H6 was supported by these data.

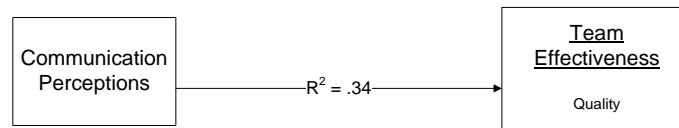


Figure 26. Hypothesis 6 findings with telemedicine

Modified Hypothesis 7a Results

H7a: The change in transactive memory systems among the team members within the T-ICU will be positively related to a change in timeliness of team effectiveness under the conditions of telemedicine.

To test the effect of a change in transactive memory systems among team members on the change in timeliness of team effectiveness, I used two regression analyses. When telemedicine was unavailable, the change of transactive memory systems significantly predicted 32.9% of the variance in the change of timeliness of team effectiveness ($R^2 = .33$, Adjusted $R^2 = .30$, $F(1, 24) = 11.76$, $p < .01$). Conversely, with the availability of telemedicine, there was no predictive value of the change in transactive memory systems on the change in timeliness of team effectiveness ($R^2 = .02$, Adjusted $R^2 = -.05$, $F(1, 14) = .31$, $p = .58$). Consequently, H7a was not supported and is actually significant in an opposite manner than I originally hypothesized.

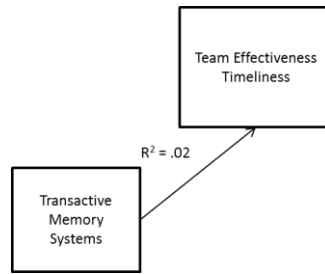


Figure 27. Hypothesis 7a findings with telemedicine

Modified Hypothesis 7b Results

H7b: The change in transactive memory systems among the team members within the T-ICU will be positively related to a change in quality of team effectiveness under the conditions of telemedicine.

To test the effect of the change in transactive memory systems among team members on the change of quality of team effectiveness, I also implemented two regression analyses. When telemedicine was unavailable, the change in transactive memory systems significantly predicted 36.4% of the variance in the change of timeliness of team effectiveness ($R^2 = .36$, Adjusted $R^2 = .34$, $F(1, 24) = 13.76$, $p < .01$). Contrarily, with the availability of telemedicine, there was no predictive value of the change in transactive memory systems on the change of quality of team effectiveness ($R^2 = .02$, Adjusted $R^2 = -.05$, $F(1, 14) = .31$, $p = .58$). Subsequently, H7b was not supported and is actually significant in an opposite manner than I originally hypothesized.

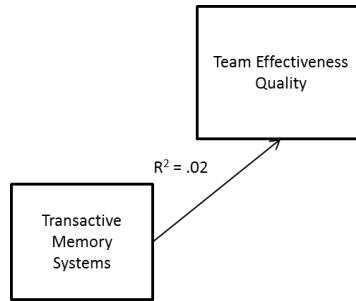


Figure 28. Hypothesis 7b findings with telemedicine

Modified Hypothesis 8 Results

H8: Psychological safety will moderate the relationship between telemedicine and attendance, such that, when psychological safety is high, there will be more attendance during the rounds in the telemedicine group.

Due to the situational constraints discussed previously, I was only able to measure attendance at the group level. Meanwhile, psychological safety was measured at the individual level. As such, I was not able to connect attendance data to the individual psychological safety data. Thus, I was unable to test H8.

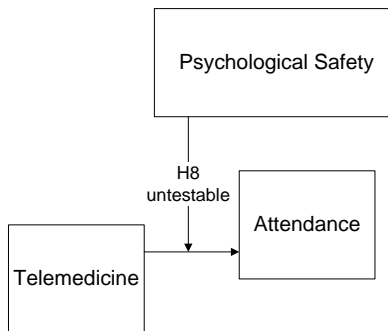


Figure 29. Hypothesis 8 findings

Modified Hypothesis 9 Results

H9: Psychological safety will moderate the relationship between telemedicine and task-based communication density, such that when psychological safety is high, will have more task-based communication density among the team members during rounds in the telemedicine group.

Akin to H8, due to situational constraints regarding data collection, I was unable to test H9.

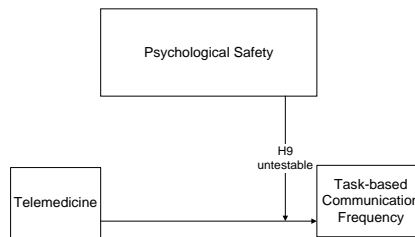


Figure 30. Hypothesis 9 findings

For a summary of the R^2 differences pertaining to all of the testable hypotheses corresponding to the survey data, refer to Table 11. Also, for a summary of the outcomes for all hypotheses, see Table 12.

Table 11. *Summary of R^2 Differences*

Hypothesis	R^2 (Telemedicine)	R^2 (No Telemedicine)	ΔR^2^*
H4A	.02	.10	-.08
H5A	.26	.02	+.24
H6	.34	.14	+.20
H7A	.02	.33	-.31
H7B	.02	.36	-.34

Table 12. *Summary of Hypotheses Results*

Hypothesis	Outcome
H1: Telemedicine will be positively related to clinicians attending rounds within the T-ICU.	Significant
H2: Telemedicine will lead to a greater task-based communication density among the team members during rounds within the T-ICU.	Significant
H3a: Attendance among the team members during rounds will be positively related to task-based communication density among team members within the T-ICU.	Non-significant
H3b: Attendance will partially mediate the effect of telemedicine on task-based communication density such that attendance will increase task-based communication density when telemedicine is present.	Un-testable
H4a: A change in communication perceptions will be positively related to a change cognitive-based trust among the team members within the T-ICU under the conditions of telemedicine.	Non-significant
H4b: A change in communication perceptions will partially mediate the effect of telemedicine on a change in cognitive-based trust such that a change in communication perceptions will be positively related to a change cognitive-based trust under the conditions of telemedicine.	Un-testable
H5a: A change in communication perceptions among the team members will be positively related to a change in transactive memory systems among the team members within the T-ICU under the conditions of telemedicine.	Significant
H5b: A change in communication perceptions will partially mediate the effect of telemedicine on a change in transactive memory systems such that a change in communication perceptions will be positively related to a change in transactive memory systems when under the conditions of telemedicine	Un-testable
H6: A change in communication perceptions among the team members within the T-ICU will be positively related to a change in quality of team effectiveness under the conditions of telemedicine.	Significant
H7a: A change in transactive memory systems among the team members within the T-ICU will be positively related to a change timeliness of team effectiveness under the conditions of telemedicine.	Non-significant
H7b: A change in transactive memory systems among the team members within the T-ICU will be positively related to a change in quality of team effectiveness under the conditions of telemedicine.	Non-significant

Hypothesis	Outcome
H8: Psychological safety will moderate the relationship between telemedicine and attendance, such that when psychological safety is high, there will be more attendance among the team members during rounds the in telemedicine group.	Un-testable
H9: Psychological safety will moderate the relationship between telemedicine and task-based communication density, such that when psychological safety is high, there will be more task-based communication frequency among the team members during rounds the in telemedicine group.	Un-testable

Exploratory Analysis Results

Behavioral Data

To understand if there were any additional behavioral differences in rounds performed utilizing telemedicine compared to rounds that did not leverage telemedicine, I conducted independent-samples t tests. There was a significant difference in how long patients were discussed (in minutes) between rounds where telemedicine was not available nor used ($M = 9.08$, $SD = 1.63$) and rounds with telemedicine available and used, $M = 6.17$, $SD = .94$, $t(25) = 5.12$, $p < .01$, mean difference 2.91, 95% CI: 1.89 to 3.93 (eta squared = .51). Next, after dummy coding insufficient time, there were significant differences in the explicit mentions of not having sufficient time to discuss patients between rounds where telemedicine was not available nor used, ($M = .24$, $SD = .44$) and rounds where telemedicine was available and used, $M = .00$, $SD = .00$, $t(25) = 2.22$, $p < .05$, mean difference = .24, 95% CI: .01 to .46 (eta squared = .17). I should point out that the mean and standard deviation is 0 because there no mentions of running out of time during rounds with telemedicine using telemedicine.

Survey Data

Shift (i.e., day vs. night) Comparison

Because the night shift staff only completed surveys at T1, all analyses within this section will utilize that respective data. To determine any mean differences between the staff that work exclusively during the day shifts and the staff that work solely during the night shifts, I conducted an independent-samples t-test. The differences in cognitive-based trust between the day shifts, ($M = 5.73$, $SD = 1.08$) and the night shifts ($M = 4.56$, $SD = .69$), were approaching significance, $t(14) = 2.00$, $p = .07$, mean difference = 1.17, 95% CI: -.08 to 2.41 (eta squared = .22). Further, there were significant differences in communication perceptions for day shifts ($M = 5.73$, $SD = .87$) and night shifts, $M = 4.55$, $SD = .26$, $t(14) = 4.18$, $p < .01$, mean difference = 1.18, 95% CI: .58 to 1.79 (eta squared = .56). Finally, there were significant differences in the quality of team effectiveness for day shifts ($M = 5.56$, $SD = 1.05$) and night shifts, $M = 4.30$, $SD = .86$, $t(14) = 2.16$, $p < .05$, mean difference = .1.26, 95% CI: .01 to 2.52 (eta squared = .25). For a summary of the independent-samples t test results, refer to Table 13.

Table 13. *Summary of Shift Comparison Results for Month 1*

	Levene's Test for Equality of Variances	t	Sig. (2-tailed)	Mean Difference
Team Psychological Safety				
Equal Variances Assumed	.94	1.26	.23	.64
Equal Variances not assumed		.124	.27	.64
Communication Perceptions				
Equal Variances Assumed	.03	2.64	.02	1.18
Equal Variances Not Assumed		4.18	.00*	1.18
Cognitive-Based Trust				
Equal Variances Assumed	.14	2.00	.07	1.17
Equal Variances Not Assumed		2.51	.04	1.17
Transactive Memory Systems				
Equal Variances Assumed	.06	1.34	.20	.63
Equal Variances Not Assumed		2.01	.06	.63
Team Effectiveness – Timeliness				
Equal Variances Assumed	.21	1.77	.10	.99
Equal Variances Not Assumed		2.41	.04	.99
Team Effectiveness – Quality				
Equal Variances Assumed	.51	2.16	.05*	1.26
Equal Variances Not Assumed		2.40	.05	1.26

*p < .05, two tailed

Role (i.e., nurses vs. doctors) Comparison

Since some nurses and physicians completed all of the surveys, the following exploratory analyses will remain consistent with the primary survey analyses and utilize the difference scores (i.e., $Month_1 = T1-T2$ and $Month_2 = T2-T3$). Keep in mind that a negative score actually indicates that means increased, and a positive score indicates that means decreased. To identify any differences between nurses and doctors, I conducted an independent samples t-test. There were no significant differences between changes in doctors' and nurses' teamwork attitudes (i.e., trust), behaviors (i.e., communication perceptions), and cognitions (i.e., TMS). Meanwhile, under conditions without telemedicine, there were significant differences in the change of quality of team effectiveness between nurses ($M = -.10$, $SD = 1.29$) and doctors, $M = -1.13$, $SD = .73$, $t(23) = 2.43$, $p < .05$, mean difference = 1.03, 95% CI: .15 to 1.91 (eta squared = .20). During month two, when telemedicine was available, there were almost significant differences between

nurses ($M = -.26, SD = .69$) and doctors, $M = .54, SD = .42, t(13) = 2.15, p = .051$, mean difference = .80, CI: - .00 to 1.60 (eta squared = .26) for the change in timeliness of team effectiveness. Also, during the period when telemedicine was available, there were marginally significant differences between nurses ($M = -.26, SD = .69$) and doctors, $M = .54, SD = .42, t(13) = 2.15, p = .051$, mean difference = .80, CI: CI: - .00 to 1.60 (eta squared = .26) for the change in quality of team effectiveness. See Tables 14 and 15 for a summary of these results.

Table 14. *Summary of Month 1 Role Comparison Results*

	Levene's Test for Equality of Variances	t	Sig. (2-tailed)	Mean Difference
Team Psychological Safety				
Equal Variances Assumed	.47	1.18	.25	.40
Equal Variances not assumed		1.19	.25	.40
Communication Perceptions				
Equal Variances Assumed	.15	.60	.55	.18
Equal Variances Not Assumed		.59	.56	.18
Cognitive-Based Trust				
Equal Variances Assumed	.24	-.22	.83	-.14
Equal Variances Not Assumed		-.22	.83	-.14
Transactive Memory Systems				
Equal Variances Assumed	.50	.51	.61	.17
Equal Variances Not Assumed		.52	.61	.17
Team Effectiveness – Timeliness				
Equal Variances Assumed	.46	1.98	.06	.77
Equal Variances Not Assumed		2.01	.06	.77
Team Effectiveness – Quality				
Equal Variances Assumed	.17	2.43	.02*	1.03
Equal Variances Not Assumed		2.48	.02	1.03

*p < .05, two tailed

Table 15. *Summary of Month 2 Role Comparison Results*

	Levene's Test for Equality of Variances	t	Sig. (2-tailed)	Mean Difference
Team Psychological Safety				
Equal Variances Assumed	.80	-.03	.98	.40
Equal Variances not assumed		-.03	.98	.40
Communication Perceptions				
Equal Variances Assumed	.21	1.07	.31	.18
Equal Variances Not Assumed		1.45	.18	.18
Cognitive-Based Trust				
Equal Variances Assumed	.00	-1.88	.08	-.14
Equal Variances Not Assumed		-1.12	.34	-.14
Transactive Memory Systems				
Equal Variances Assumed	.14	.27	.80	.17
Equal Variances Not Assumed		.37	.72	.17
Team Effectiveness – Timeliness				
Equal Variances Assumed	.42	2.15	.05	.77
Equal Variances Not Assumed		2.72	.02	.77
Team Effectiveness – Quality				
Equal Variances Assumed	.42	2.15	.05	1.03
Equal Variances Not Assumed		2.72	.02	1.03

* $p < .05$, two tailed

Additional Relationships

Similar to the regression analyses conducted to test the hypotheses, these regressions also utilized the difference scores. To garner further insights into additional relationships with team effectiveness, I conducted other regression analyses. Specifically, when telemedicine was available, a change in communication perceptions significantly predicted 33.7% of the variance in a change in timeliness of team effectiveness ($R^2 = .34$ Adjusted $R^2 = .29$, $F(1, 14) = 7.13$, $p < .05$). To the contrary, a change in psychological safety also significantly predicted 29.1% of the variance in a change in timeliness of team effectiveness when telemedicine was unavailable, ($R^2 = .29$ Adjusted $R^2 = .26$, $F(1, 14) = 9.85$, $p < .01$). Moreover, when telemedicine was available, a change in psychological safety significantly predicted 19.9% of the variance in a change in the quality of team effectiveness ($R^2 = .20$ Adjusted $R^2 = .17$, $F(1, 14) = 5.95$, $p < .05$)

CHAPTER FIVE: DISCUSSION

Hypothesized Analyses

Behavioral Data

Hypothesis 1 posited that telemedicine would be positively related to attendance during rounds within the TICU since the mobile robot would serve as a priming mechanism for staff that may not necessarily attend because they are unaware rounds are proceeding, or they do not have enough time to attend the entire round (e.g., nurses; Bargh et al., 1996). The findings from this study did indeed support this hypothesis that the use of telemedicine is positively associated with attendance. More clinicians did in fact attend rounds when telemedicine was used. Even though the current data did not parse apart the specific roles that attended, it is reasonable to speculate that the accumulation in attendance when telemedicine was used was due to an increase in ancillary staff attendance (i.e., nurses) as opposed to an increase in primary staff (i.e., residents). The primary staff is more obliged to attend, but the ancillary staff does not possess that same obligation. Accordingly, future research should look at attendance at a more granular level to identify any roles and subsequent strategies that should be specifically targeted to enhance attendance.

Hypothesis 2 proposed an increase in task-based communication density among team members during rounds in the T-ICU when telemedicine was used. The rationale for this hypothesis is that telemedicine provides additional, shared information, which serves a mechanism for conversational grounding (Burke & Murphy, 2007). Conversational grounding is established by visual information, and telemedicine expands the parameters regarding what can

be communicated. In this instance, however, the relationship between telemedicine and task-based communication density was significant. Hence, H2 was supported. I posit that this hypothesis was supported because clinicians are able to communicate more efficiently when telemedicine is used. Communication becomes denser since clinicians are able to communicate more efficiently because they are able to answer questions and solve problems by communicating with their colleagues, but they also are able to ascertain more information visually from the telemedicine monitors. Future research should delve deeper into the relationship between telemedicine and communication. For example, future studies could examine the relationship between communication density per patient as opposed to a specific time interval. The current study investigated communication density within an eight minute period. Subsequently, it might be worthwhile to study the relationship between telemedicine and communication per patient. Additionally, future research should investigate nonverbal gestures, tonal fluctuations, or communication patterns (e.g., closed loop). Having a better understanding of this relationship could help improve team processes, states, and outcomes. Additionally, it could also provide teams guidance on what specific facets of communication should be sustained and what elements need modifications.

Hypothesis 3 suggested that attendance during rounds in the T-ICU would be positively related to task-based communication density among T-ICU team members while using telemedicine. The thinking underlying this hypothesis is that team size would positively impact team processes (i.e., communication). The data, however, did not support this assertion.

Although it may seem surprising that attendance would not be positively related to task-based

communication density, there is a reasonable explanation. As described earlier, attendance does increase during rounds with telemedicine, but the number of people communicating does not necessarily increase as well. Typically, there is a select few that contribute to the majority of the conversation with other individuals interjecting little input. Therefore, the overall communication does not automatically increase as a direct result of more people attending. In fact, the data would suggest that there is not a significant difference in the amount of people communicating during rounds regardless if telemedicine is being utilized or not. Initially, this may seem counterproductive and disadvantageous to have team members not verbally contributing to the discussion. Upon further inspection, input and communication from all members within a large team could be chaotic and lead to more conflict (Curren et al., 2001). Consequently, despite the fact that this hypothesis was not supported, this finding may be more beneficial for overall team performance and patient safety. However, future research should be conducted to determine the appropriate proportion of team size and member contribution during rounds. Likewise, future research should investigate the connections between team size, member contribution, and patient safety.

Survey Data

Prior to testing the hypothesized relationships, I conducted t-tests to identify differences in the teamwork constructs (i.e., communication perceptions, cognitive-based trust, transactive memory systems, team effectiveness, and psychological safety) under the conditions with and without telemedicine. Surprisingly, there were no statistically significant differences in any of the constructs at any time period. There are a couple of possible explanations to expound upon

these results. The first possibility is that the metrics were insufficiently specific. To elaborate, the directions instructed participants to reflect on the previous 30 days while answering the questions. However, it is possible that participants did not read those instructions thoroughly and simply answered them in a generic manner. Including more detailed information at the item level might have ameliorated this potential issue. In other words, attaining more accurate answers could have been more likely if questions were phrased as - within the past 30 days, my team communicates more frequently. Revising the phrasing to include the time frame within each item as opposed to the directions might have made that time referent more salient, thus, altering the responses accordingly.

The second reason that might explicate these findings is that the role of technology may be less influential for intact teams. This study included individuals within the T-ICU that work together fairly regularly and consistently. Furthermore, these individuals have worked together prior to the beginning of the study. Subsequently, it is possible that these clinicians have fairly solidified attitudes and perceptions of their colleagues that are not easily influenced by external factors, such as technology. In essence, how much trust one nurse has towards another may not be altered by the removal of telemedicine. However, future studies should be conducted to test this assertion. That is, future studies should investigate the impact of telemedicine in ad-hoc teams and intact teams. These are simply a few ideas for providing insights onto the relationships between telemedicine and teamwork constructs; the remainder of this section will focus on describing the findings of the hypotheses.

The original Hypothesis 4a proposed that task-based communication would be significantly related to cognitive-based trust. This hypothesis was rooted in the theory that communication and social interaction breed trust (Webber, 2008). Additionally, more opportunities to exhibit expertise serve as a database to build trust assessments (Hung et al., 2004). Unfortunately, due to the situational constraints, the original hypothesis could not be tested. Thus, the modified hypothesis stipulated that a change in communication perceptions would be positively related to a change in cognitive-based trust. The findings were non-significant, and this adjusted hypothesis was not supported.

There are a few reasons why the data did not support this assertion. One plausible explanation that is applicable here and will become a common theme henceforth is the inadequate sample size (i.e., $N = 16$, Month₂). The means of cognitive-based trust were trending in the predicted direction, so it is possible that the sample size was not large enough to detect any significance between communication perceptions and cognitive-based trust. Another potential reason why this was a non-significant finding could be attributed to communication metric utilized for this analysis. The original metric tapped into the density of communication behaviors, but the metric leveraged for this analysis was targeting communication perceptions. The mere perceptions of communication may not be sufficient to in fact enhance cognitive-based trust; actual communication and interactions are likely the more appropriate mechanisms that build such trust.

A third explanation for this apparent lack of significance between communication perceptions and trust is that there could be other, more influential elements to elevating

cognitive-based trust besides communication perceptions. For example, surface-level characteristics (i.e., observable demographic traits) and imported information (e.g., preconceptions or preexisting information) could contribute more to trust development. In fact, previous research has indicated that such surface-level cues are detrimental to communication effectiveness and even trust development (Stahl, Maznevski, Voigt, & Jonsen, 2010). Moreover, Salancik & Pfeffer (1978) have proposed that imported information is considered more heavily in complex situations, such as providing patient care.

Clearly, trust is a complex phenomenon, and as mentioned much earlier, some argue that it is multi-dimensional – comprising of cognitive-based trust and affective-based trust (McAllister, 1995). Since this study focused on cognitive-based trust, future research should examine the relationship between communication and affective-based trust when utilizing telemedicine. In addition to the dimensionality aspects of trust, researchers also argue about the distinction or lack thereof between trust and distrust. More specifically, some researchers suggest that trust and distrust are one construct that simply vary along the same continuum (Schoorman et al., 2007). Meanwhile, others propose that trust and distrust are in fact two separate constructs (Lewicki, McAllister, & Bies, 1998). This long standing debate could benefit from future studies dissecting the connection between communication and distrust, especially in the healthcare field as few studies have explored the antecedents and outcomes associated with distrust, and virtually no studies have studied distrust in the context of telemedicine.

The next hypothesis, 5a, proposed that task-based communication frequency would positively lead to transactive memory systems among team members within the T-ICU when

telemedicine was present. This hypothesis was built on the belief that increased communication frequency provides more opportunities for rehearsal in the encoding, storage, and retrieval process (Hollingshead, 1998). Also, communication frequency provides additional instances for team members to learn about each other's knowledge set (Kanawattanachai & Yoo, 2007). In this study, unfortunately, the original hypothesis could not be tested due to practical limitations. Therefore, the tested hypothesis investigated the relationship between the change in communication perceptions and TMS under conditions of telemedicine. According to the data, the adapted hypothesis was supported. Simply stated, a change in communication perceptions are positively related to a change in TMS under conditions of telemedicine. To garner additional insights into the relationship between communication and TMS, future investigators could explore where communication is most important. That is, is communication more vital during the encoding phase or retrieval phase? Helping teams understand this dynamic could offer information on how to effectively develop and maintain an optimal TMS.

The sixth original hypothesis suggested that communication frequency would lead to better quality of team effectiveness in the presence of telemedicine. Research has repeatedly posited that communication is essential for effective team outcomes (Mesmer-Magnus & DeChurch, 2009). Communication is foundational for sustaining up-to-date information (Sims & Salas, 2007), anticipating team member's needs (Salas et al., 2005), integrating new perspectives, as well as providing opportunities to address questions and concerns (Hoegl & Gemuenden, 2001). Despite the present study not testing the original hypothesis, it did test the modified hypothesis of a change in communication perceptions being positively related to a

change in quality of team effectiveness. The results of this study do indeed support the modified hypothesis that a change in communication perceptions is positively related to a change in quality of team effectiveness under conditions of telemedicine. Obviously, quality is only one facet of team effectiveness; therefore, future researchers should unpack the relationship between communication and the remaining components of team effectiveness (i.e., timeliness, goals, customers, and productivity). It is conceivable that communication may have differential effects on these various team effectiveness dimensions; however, empirical data is needed to truly determine the extent that communication impacts team effectiveness.

The next hypotheses, H7a/b, focused on a change in TMS being positively related to a change in better timeliness and quality of team effectiveness under conditions of telemedicine. The primary reasoning behind these hypotheses was that a stronger TMS would reduce the cognitive workload of each individual team member since each person is responsible for less information overall and can focus on knowing more specialized information (Peltokorpi & Manka, 2008). Furthermore, a stronger TMS facilitates team effectiveness by enabling more efficient planning and problem solving by aligning member expertise to problems (Lewis, 2004). The data, though, did not support these hypotheses. In fact, the data indicated that there is a significant relationship between the change in TMS and a change in timeliness and quality of team effectiveness when telemedicine is unavailable. There are several explanations that may elucidate this finding.

The first potential explanation for why this hypothesis was non-significant pertains to the TMS measure. To test this hypothesis, I utilized a widely accepted measure developed by Lewis

(2003), which focused on one's appraisal of the transactive memory system. The measure I initially intended to employ was one developed by Austin (2003). This measure is a more accurate and a better representation of TMS because it taps into the actual system as opposed to one's appraisal of it. Unfortunately, it could not be used because few participants successfully completed it. They may not have filled out this measure because instructions were not clear enough or were insufficient. A second reason participants may not have completed it was because of time constraints; all clinicians completed the surveys during their shift. As a result, they may not have had time to thoughtfully consider each colleague and write down the corresponding name. Finally, a third reason why this measure was completed unsuccessfully is that participants may have felt uncomfortable explicitly selecting individuals, which is a requirement for Austin's TMS measure. Irrespective of the reason, it could not be used as planned. This shift in TMS measurement could be one potential explanation for why a change in TMS did not significantly predict a change in timeliness or quality of team effectiveness when telemedicine was available.

A second probable explanation for these non-significant findings is the sample size. The sample size was substantially larger during the month when telemedicine was unavailable (i.e., $N = 26$) compared to the month when telemedicine was available (i.e., $N = 16$). Perhaps, a change in TMS is significantly influential for team effectiveness regardless of the availability of telemedicine. However, the sample size for the telemedicine condition was so small that the analysis was unable to have enough statistical power to detect a significant relationship.

A final explanation is that a change in TMS may be more important for a change in timeliness and quality of team effectiveness in situations where less visual information is accessible. Team members must rely on one another to attain certain aspects of information. However, when telemedicine is present, that information is presented visually, readily available, and automatically shared amongst the team. To illustrate, without telemedicine, it may be necessary for the attending physician to ask the resident if a patient has been intubated. Thus, the resident needs to have that expertise, and the attending needs to be cognizant of which team member should be solicited. Contrarily, with telemedicine, the attending physician would not need to ask the resident about the patient's intubation status because it can be obtained by simply viewing the telemedicine monitor. Since telemedicine affords more visual cues that are easily accessible, it is less crucial to rely on team members for that same information. Consequently, a stronger TMS may be more critical when that visual information is unavailable, that is, without telemedicine.

Unquestionably, there are still many questions unanswered regarding TMS and team effectiveness, particularly as it pertains to telemedicine. Therefore, future researchers should continue to explore these relationships. For example, investigators should determine which facets of transactive memory (i.e., specialization, credibility, and coordination) are integral for team effectiveness. Similarly, future investigators should study which components of team effectiveness (e.g., productivity, goals, and customers) are influenced by TMS. Understanding the relationship between all of the elements of TMS and team effectiveness could guide future

teams on how to create and sustain an optimal TMS as well as maximize yet hone team effectiveness while leveraging or abandoning telemedicine accordingly.

Exploratory Analyses

In addition to the hypothesized relationships, I also conducted exploratory analyses within the behavioral and survey data. There were two significant findings within the exploratory analyses of the behavioral data. The first finding was a significant difference in how long patients were discussed (in minutes) during rounds with telemedicine unavailable and not used and rounds with telemedicine available and used. Rounds that leveraged telemedicine discussed patients significantly shorter than rounds that did not use telemedicine. This may seem counterintuitive initially since telemedicine provides more information; hence, there is more to discuss. However, after further inspection, there could be a reasonable explanation. Since telemedicine provides additional visual information, it might be unnecessary to verbally discuss such data. For instance, it may be unessential to communicate patient information that can be extracted from the telemedicine monitor. Leveraging the previous intubation example, the attending and resident do not need to dedicate time to verbally discuss a patient's intubation status when the answer can be attained visually yet silently. Simply stated, questions can be answered without discussing them by just utilizing the information presented on the telemedicine monitor. As a result, communication can become more efficient under conditions of telemedicine compared to conditions without it.

Similarly, the other noteworthy finding within the behavioral data was that there were significantly more explicit mentions of not having enough time to discuss patients when

telemedicine was unavailable and not used and when telemedicine was available and used. In other words, clinicians had insufficient time to discuss patients without telemedicine. On other hand, clinicians did have adequate time to discuss patients with telemedicine. The rationale for this finding corresponds quite well with the previous finding. Attendings, residents, fellows, and others were able to discuss each patient more efficiently in the presence of telemedicine due to the accessibility of information such that they never explicitly mentioned not having enough time.

The exploratory analyses within survey data also revealed some interesting findings. First, there were quite a few differences between the night and day staff. In essence, the night staff had almost significantly less cognitive-based trust compared to their daytime counterparts. Moreover, the night shift had significantly less favorable communication perceptions and less quality of team effectiveness in comparison to the day shift staff. This finding aligns with previous research that has suggested that night shift staff suffer from more anxiety and irritability and experience more conflict and fatigue than their daytime counterparts (Wilson, 2002). Research has also suggested that night shift staff have poorer performance in comparison to the daytime equivalents (Muecke, 2005; Wilkinson, Allison, Feeney, & Kaminska, 1989). Such negative outcomes are typically attributed to disrupted circadian rhythms (Harrington, 2001; Smith-Coggins, Rosekind, Buccino, Dinges, & Moser, 1997) and greater workloads due to more nighttime admissions and turnover (Morales, Peters, & Afessa, 2003). Due to this empirical research, it seems logical that the findings of this study also suggest that the night shift would possess less team processes (i.e., communication), states (i.e., cognitive-based trust), and

outcomes (i.e., team effectiveness). Realizing the detrimental impact of performing during the night shift, future studies should target mechanisms on how to improve the necessary teamwork processes and states and ultimately outcomes. Considering that teamwork is fundamental for providing quality patient safety and care, it is vital that strategies are developed and implemented to assist this vulnerable population (i.e., night staff).

Other exploratory analyses, investigating differences between roles (i.e., nurses vs. doctors), revealed that there were significant differences in the change in quality of team effectiveness under conditions without telemedicine, and there were almost significant differences in the change of timeliness of team effectiveness between doctors and nurses. Indeed, doctors had significantly better quality and marginally significantly better timeliness of team effectiveness compared to nurses under conditions without telemedicine. Furthermore, under conditions of telemedicine there were almost significant differences between nurses and doctors both in the change of timeliness and quality of team effectiveness. With doctors having being almost significantly better than nurses in both the change of timeliness and quality of team effectiveness under conditions of telemedicine. It is likely that given a larger sample size, doctors would have had significantly higher timeliness and quality of team effectiveness when telemedicine was present compared to nurses.

It is difficult to identify why such differences between nurse and physicians would exist; however, I do have several possible ideas. The first idea focuses on their scope of practice within their respective roles. Nurses are certainly capable of executing a number of tasks, but many of these tasks require a physician to write an order before it can be implemented. In essence, when a

nurse can perform a task is contingent upon when a physician can draft the order. As a result, nurses may perceive that tasks take longer to perform compared to physicians, thereby, impacting the timeliness of the team. Related to this idea, another option is that these differences may be attributable to a locus of control. Physicians may have a larger internal locus of control (i.e., belief to control their own outcomes) compared to their nursing colleagues since as just previously stated they have the responsibility of generating care plans and drafting orders. Such control may influence the extent that staff perceives their team to be effective.

Another idea is that physicians have structured and dedicated time to devote to patient care and plan management. Further, it is the cultural norm that residents and attendings work intimately together to devise care plans for all of the patients. This dedicated time along with the relationship norms among doctors may facilitate better team effectiveness in comparison to nurses. Undoubtedly, all of these explanations are simply ideas and need further testing to determine their accuracy. Such research would not only shed light from an academic perspective of understanding the science of teams to a greater extent, but it would also facilitate the creation of mechanisms to improve team effectiveness among nurses. Nurses also are an integral part of patient care, so it is imperative that all team members regardless of their role have ample team effectiveness.

The exploratory analyses investigating the relationships between constructs suggested that under the conditions of telemedicine, a change in communication perceptions significantly contributed to change in timeliness of team effectiveness. This finding is in line with previous evidence, which states that communication is essential for successful team effectiveness,

especially in the medical field (Salas et al., 2008). Communication enables timeliness because team members are more capable of anticipating needs and executing plans (Salas et al., 2009). Although the relationship of communication and team outcomes has been studied extensively, there has been practically no research that has examined this relationship in the context of telemedicine. To provide an even deeper yet more comprehensive assessment of this relationship, future studies should examine the influence of communication on the other elements of team effectiveness (e.g., goals, productivity, etc.) in the context of telemedicine. Garnering such information would foster the development of communication strategies to optimize team effectiveness. In addition, future investigators could explore the characteristics (e.g., open – not holding back information) and tools (e.g., closed-loop) of communication that are most integral for team effectiveness in relation to telemedicine.

Finally, the last exploratory analyses determined that a change in psychological safety was important for both a change in timeliness and quality of team effectiveness when telemedicine was unavailable. This finding initially seemed counterintuitive. However, there could be a few reasons why a change in psychological safety would only significantly predict a change in team effectiveness in the absence of telemedicine. One possibility is simply that the smaller sample size during the period when telemedicine was present was inadequate to have enough statistical power to detect a relationship. Future studies conducted with larger sample sizes would help identify if a relationship exists between psychological safety and team effectiveness when telemedicine is present.

Another possibility is that psychological safety and team effectiveness also are impacted by team size. Earlier research has indicated that team size influences climate within the healthcare setting. More specifically, smaller team sizes were associated with better climate (Proudfoot et al., 2007). With these findings, it seems reasonable that psychological safety and team size may also be related, with smaller team size being more favorable for better psychological safety. Individuals in smaller teams tend to have more cohesion, and it is easier to share experiences and exchange information, two tenets of psychological safety, in such smaller teams (Kayes, Kayes, & Kolb, 2005). Finally, it is easier to be more inclusive of all team members, another fundamental element of psychological safety, in smaller teams. Given that attendance was significantly smaller in rounds conducted when telemedicine was unavailable and psychological safety potentially being related to team size, it provides a starting point for understanding why psychological safety is related to team effectiveness when telemedicine is unavailable. Unquestionably, though, substantial research is needed to support this assertion. Empirical evidence examining the connection between psychological safety and team size is necessary, especially as it pertains to telemedicine.

Theoretical and Practical Implications

With regard to advancing the science of teams, this study provides insights into the relationships of the teamwork constructs in a planning task within a field setting. Often times, field studies employ a metric of team performance as the primary outcome variable. However, the disadvantage to such metrics is that they do not afford for comparisons across studies since team performance is frequently, extremely context specific. This study leveraged team

effectiveness as the outcome, and this measure fosters comparisons across samples and studies by utilizing dimensions that are more generalizable irrespective of the context.

In terms of advancing the practice of telemedicine, the foremost implication of this study is the application of telemedicine and its impact on teams and teamwork. Telemedicine, as it pertains to teamwork and rounds, is not a “silver bullet” solution for enhancing the presented team attitudes, behaviors, and cognitions. However, it should also not be completely abandoned and viewed as a complete detriment. Telemedicine is related to enhancements in specific components of teamwork while not impacting others. As a result, institutions need to thoroughly consider the areas of teamwork that they want to sustain or the elements they would like to enhance. To elaborate, if a hospital is having issues with attendance during rounds (i.e., attendance is inadequate), then telemedicine might be a potential solution to help resolve this dilemma. However, if psychological safety is a problematic area and needs improvement, it might be better to forgo telemedicine. Ultimately, whether or not telemedicine should be utilized during rounds with regards to teamwork is completely contingent upon the specifics of the circumstances the institutions.

Another implication is that this study offers information regarding the role on technology on teams. Technology is a staple in our everyday lives and even in patient care, so understanding its role on teamwork is becoming necessary. Furthermore, human-robot teams will gain momentum and join in the forefront of team research as technology continues to evolve and grow. Due to the expansion in technology, identifying the underpinnings of human-robot teams

and how to maximize functionality and performance will become very valuable. Knowing how these human-robot teams operate best will be crucial to enhancing their effectiveness.

Study Limitations and Future Research

Similar to all research, this study is not without limitations. Some of the limitations were presented earlier as I described the findings in the discussion, but there were also some overarching limitations and ideas for future research that could be expounded upon. One of the most noteworthy limitations is the sample size. The small sample size substantially impacts the statistical power and the ability to interpret the results accurately. Hence, it is possible that the lack of significant findings could be attributable to an inadequate sample size. As such, future research would benefit by conducting studies with considerably larger sample sizes. In particular, studies should attempt to include a better representation of the various clinical roles (e.g., nurse managers, pharmacists, nurse anesthetist, etc.) and subspecialties (e.g., anesthesia and surgical residents and fellows). Likewise, future studies should investigate using samples from different departmental contexts, such as the surgical intensive care unit, labor and deliver, and oncology, to name a few examples.

In addition to the previously mentioned idea, another potential limitation is the generalizability of the findings. This study focused on a very specific task, rounds, which is primarily a planning task. Patient care is a complex, dynamic process that involves numerous yet very different tasks and skills. It is likely that the impact of telemedicine would vary greatly depending upon the task-at hand. As such, future investigators should explore the influence of telemedicine on other tasks, such as problem solving (e.g., diagnostics), advising (e.g.,

consultations), or psychomotor (e.g., surgery). Examining the association between different tasks and telemedicine will help providing insights to others on the circumstances and applications in which telemedicine will be most effective.

The next aspect pertaining to the generalizability of the study is the extent that telemedicine impacts team processes, states, and outcomes. This study focused on a subset of teamwork since it was out of the scope to examine all aspects of teamwork. Therefore, future studies should investigate the relationship between telemedicine and other integral team attitudes (e.g., team orientation, collective efficacy, and cohesion), behaviors (e.g., mutual performance monitoring, coordination, and backup behavior), and cognitions (e.g., team situational awareness). Telemedicine likely has differential effects on each of the various facets of teamwork; thus, it is necessary to explore all of these relationships. For instance, telemedicine may substantially impact team situation awareness, yet minimally affect mutual performance monitoring. Ultimately, more empirical evidence detailing the association between telemedicine and teamwork is necessary.

Another limitation related to generalizability is that this study utilized perceptions in lieu of objective metrics of team outcomes. It was unfeasible to collect patient outcomes in this study; however, the findings related to the perceptions of team effectiveness may not generalize to actual team effectiveness and related patient or organizational outcomes. These perceptions do provide valuable insight and should not be discredited completely, but future research could benefit by studying additional outcomes. In particular, future endeavors should include objective metrics of team performance (e.g., accuracy or error rates) and more importantly patient

outcomes (e.g., central line infections). Perceptions of team outcomes are one minor step in assessing the larger picture; however, they are insufficient. More is needed.

A final limitation of this study is the lack of random assignment and true experimentation. Random assignment affords for understanding causal relationships as opposed to correlational relationships. Because quasi-experimental designs do not inherently entail random assignment it is impossible to say with complete certainty that the manipulation, in this case the availability and use of telemedicine, is the sole factor for causing any fluctuations in trust, communication perceptions, TMS, and team effectiveness. Quasi-experimental designs are common within field research and oftentimes expected, particularly within the in-patient medical setting, yet it would still be worthwhile for future researchers to conduct true experimentation. Such research would be able to provide more definitive evidence on the connection between telemedicine and teamwork.

Conclusion

Medical errors remain a problematic issue within the medical community with hospital acquired infections as well as teamwork being some of the significant contributors to such adverse events. Attempting to alleviate these problems, designers, administrators, and clinicians have developed technology, such as telemedicine. However, little research has been conducted to understand the relationship between telemedicine and teamwork. The purpose of this study was garner insights regarding the effect of telemedicine on clinical provider's teamwork behaviors and subsequent attitudes and cognitions during a common task, daily rounds. To uncover these relationships, this study investigated the influence of telemedicine on teamwork during rounds

conducted with and without telemedicine. The results of this study demonstrate that the relationships between teamwork dimensions are impacted differentially depending upon the availability and use of telemedicine during rounds. More specifically, when telemedicine was available and used, attendance increased, a change in communication perceptions significantly predicted a change in TMS, and a change in communication perceptions led to a change in quality of team effectiveness. Additionally, communication was more efficient such that clinicians were able to discuss patients quicker yet had adequate time to discuss each patient. Conversely, when telemedicine was unavailable, a change in TMS and psychological safety were associated with a change in timeliness and quality of team effectiveness. Further, this study also revealed that the night shift had less favorable team attitudes (i.e., cognitive trust) and behaviors (i.e., communication perceptions) compared to their daytime counterparts with the unavailability of telemedicine. Finally, this study provided evidence suggesting that doctors had a change in timeliness and quality of team effectiveness irrespective of the availability of telemedicine.

Although all of the findings and even lack of significant findings are interesting, they are by no means the final verdict, as substantial research is needed in this crucial area. This study is extremely innovative in that telemedicine and teamwork has not been studied previously. It is my hope that this study will serve as starting point for future research and that others will continue to explore the role of telemedicine on teamwork with a variety of larger samples in numerous contexts performing other tasks.

APPENDIX A: DEMOGRAPHICS

Scale

See below for each question

Items

1. What is your sex:
 Male
 Female
2. What is your age?

3. What is your race or ethnic background? (check all that apply):
 White/Caucasian, Anglo, European American; not Hispanic
 Black/African American
 Hispanic or Latino, including Mexican American, Central American
 Asian or Asian American, including Chinese, Japanese
 Pacific Islander or Native Hawaiian
 American Indian
 Alaskan Native
 Middle Eastern, including Northern African, Arabic, West Asian, and others

 Other: Please Describe _____
4. Where were you born? (City, State; Country if outside the US)

5. Are you fluent in more than one language? If so, which languages, in order of most fluent to least fluent?

6. What is your role?
 Nurse
 Attending physician
 Resident
 Other: _____
7. How long have you been in your role?
_____ years _____ months _____ days
8. How many hours a week do you work?

9. What shift do you typically work?

Day

Night

Both

10. What days do you typically work?

Weekdays

Weekends

Both

11. Are you an on-call worker?

Yes

No

12. Do you have any degrees or certifications?

Yes

No

If Yes, please list them here: _____

13. How often do you typically work with telemedicine (e.g. telemedicine rounding robot)?

1 = Never → 7 = Always

14. I have worked with telemedicine (e.g. telemedicine rounding robot)?

Yes

No

APPENDIX B: TEAM PSYCHOLOGICAL SAFETY SCALE

Scale:

1= never → 7= always

1. If you make a mistake on this team, it is often held against you.
2. Members of this team are able to bring up problems and tough issues.
3. People on this team sometimes reject others for being different.
4. It is safe to take a risk on this team.
5. It is difficult to ask other members of this team for help.
6. No one on this team would deliberately act in a way that undermines my efforts.
7. Working with members of this team, my unique skills and talents are valued and utilized.

APPENDIX C: COMMUNICATION PERCEPTIONS

Scale:

1 = Strongly Disagree → 7 = Strongly Agree

1. There was frequent communication within the team.
2. The team members communicated often in spontaneous meetings, phone conversations, etc.
3. The team members communicated mostly directly and personally with each other.
4. There were mediators through whom much communication was conducted. R
5. Project-relevant information was shared openly by all team members.
6. Important information was kept away from other team members in certain situations. R
7. In our team there were conflicts regarding the openness of the information flow. R
8. The team members were happy with the timeliness in which they received information from other team members.
9. The team members were happy with the precision of the information received from other team members.
10. The team members were happy with the usefulness of the information received from other team members.

APPENDIX D: TRANSACTIVE MEMORY SYSTEM SCALE

Part 1: Take a look at the list of skills that have been identified as being relevant for your work environment. Now, think about your colleagues. For each skill on the list, please identify whom you believe has the most expertise in that particular skill area. You may select more than one person for each skill if desired. For the following, please identify the name of the colleague next to the skill they have expertise in:

Example of a skills list:

Skill/Knowledge Area	Type of Colleague with Expertise
1. Knowledge of patient background (e.g. past/history)	
2. Knowledge of patient's affliction (e.g. Current Status)	
3. Monitoring Vital Signs (e.g. Current Status)	
4. Developing Treatment for Patient	
5. Evaluation of Treatment (e.g. treatment quality)	
6. Patient Management (e.g. caring for the patient/administering treatments)	
7. Education of Junior Clinicians	
8. Leading Discussions During Rounds (e.g. Team Coordination)	

Part 2: Take a look at the list of skills that your colleagues have identified as being relevant for your work environment. Now, think about your own expertise for each skill. For each skill on the list, please rate your own level of ability for each particular skill area. Use the following scale:

Scale:

1 = very low ability → 7 = very high ability

Example of a skills list:

Skill/Knowledge Area	Rate Your Level of Ability (1 to 5)
1. Knowledge of patient background (e.g. past/history)	
2. Knowledge of patient's affliction (e.g. Current Status)	
3. Monitoring Vital Signs (e.g. Current Status)	
4. Developing Treatment for Patient	
5. Evaluation of Treatment (e.g. treatment quality)	
6. Patient Management (e.g. caring for the patient/administering treatments)	
7. Education of Junior Clinicians	
8. Leading Discussions During Rounds (e.g. Team Coordination)	

APPENDIX E: TRANSACTIVE MEMORY SYSTEMS SCALE

Scale:

1 = Strongly Disagree → 7 = Strongly Agree

Specialization

1. Each team member has specialized knowledge of some aspect of our project.
2. I have knowledge about an aspect of the project that no other team member has.
3. Different team members are responsible for expertise in different areas.
4. The specialized knowledge of several different team members was needed to complete the project deliverables.
5. I know which team members have expertise in specific areas.

Credibility

1. I was comfortable accepting procedural suggestions from other team members.
2. I trusted that other members' knowledge about the project was credible.
3. I was confident relying on the information that other team members brought to the discussion.
4. When other members gave information, I wanted to double-check it for myself. (R)
5. I did not have much faith in other members' "expertise." (R)

Coordination

1. Our team worked together in a well-coordinated fashion.
2. Our team had very few misunderstandings about what to do.
3. Our team needed to backtrack and start over a lot. (R)
4. We accomplished the task smoothly and efficiently.
5. There was much confusion about how we would accomplish the task. (R)

APPENDIX F: COGNITIVE-BASED TRUST SCALE

Scale:

1. Not at all → 6. Very Much so

To what extent do you feel:

1. Assured that the other clinicians will make intelligent decisions?
2. Faith that the other clinicians can do the task at hand?
3. Confident in the other clinician's ability to complete a task?
4. Afraid that the other clinicians will make a mistake?
5. Compelled to keep tabs on the other clinicians to be sure things get done?
6. Certain that the other clinicians will perform well?
7. Paranoid that other clinicians will fail?
8. Worried that other clinicians will do something wrong?

APPENDIX G: TEAM EFFECTIVENESS

Scale:

1 = strongly agree → 7 = strongly disagree

Timeliness

1. This team meets its deadlines.
2. This team wastes time.
3. The team provides patient care on time.
4. This team is slow.
5. This team adheres to its schedule.
6. This team finishes its work in a reasonable amount of time.

Quality

1. This team has a low error rate.
2. This team does high quality work.
3. This team consistently provides high-quality output.
4. This team is consistently error-free.
5. This team needs to improve its quality of work.

APPENDIX H: UCF APPROVAL OF HUMAN RESEARCH LETTER



University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: UCF Institutional Review Board #1
FWA00000351, IRB00001138

To: Eduardo Salas and Co-PI: Elizabeth H. Lazzara

Date: October 31, 2012

Dear Researcher:

On 10/31/2012, the IRB approved the following human participant research until 10/30/2013 inclusive:

Type of Review:	UCF Initial Review Submission Form
Project Title:	Decision Making with Telemedicine in an Intensive Care Unit
Investigator:	Eduardo Salas
IRB Number:	SBE-12-08786
Funding Agency:	Telemedicine and Advanced Technology Research Center (TATRC)
Grant Title:	Innovative Approaches to Combat Education
Research ID:	N/A

The Continuing Review Application must be submitted 30 days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at <https://iris.research.ucf.edu>.

If continuing review approval is not granted before the expiration date of 10/30/2013, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) from U of Miami is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 10/31/2012 10:43:24 AM EST

IRB Coordinator

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