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The role of the circulating registered nurse in communicating and fostering relationships and the impact on time spent in the operating room

By

Kent Wadley Haythorn
Doctor of Philosophy

Nursing

Melinda K. Higgins, PhD

Advisor

Susan Shapiro, RN, PhD, FAAN

Committee Member

Sharon Pappas, RN, PhD, NEA-BC, FAAN

Committee Member

John Sweeney, MD, FACS

Committee Member

Accepted:

Kimberly Jacob Arriola, MPH, PhD
Dean of the James T. Laney School of Graduate Studies

Date

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Kent Wadley Haythorn
MS, Nazareth College 2002

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An abstract of
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Abstract

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By Kent Wadley Haythorn

The aims of this study were to describe the relationships and communication patterns in the operating room and understand the role of the circulating registered nurse in relation to surgery case length duration. Despite numerous attempts to decrease errors in the operating room, they continue to occur. Longer surgical cases are associated with increased numbers of surgical errors, possible infection, and time spent in the operating room. The circulating registered nurse role in managing surgical case length duration is not well documented in the literature; the focus tends to be on the surgeon. The CRN is the critical role linking the surgical field to everything happening outside the surgical field necessary for success. What is unique about the role of circulating registered nurses is that they have a more global perspective than the surgeon of events that may affect surgical case length.

To investigate this complex environment and the CRN's role within it, two novel approaches were used. The Relational Coordination theoretical framework was used to survey operating room staff to gain understanding of communication and relationships in the operating room. Social Network Analysis was then used to analyze data gathered by directly observing surgical procedures. This provided a deeper understanding of the roles in the OR and how they communicate with each other during surgery.

What was discovered is that there were 16 different individuals with roles that were important to surgical procedures. Of those, five were present in all the surgeries observed. Sociograms elegantly described communication patterns. Sociograms that had more distinct clusters (higher modularity, lower density) with a single leader directing the team appear to spend less time in the operating room. For most of the cases, the surgeon and the circulating registered nurse share prominence and are key roles for communication both inside and outside the surgical field.

This study is important because it utilized two different approaches to investigate issues with communication and relationships in the operating room including a unique analysis of real-time surgeries using social network analysis. These results also help highlight the critical role of the circulating registered nurse in managing time and safety in the operating room.

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Chapter 1:

Introduction

Introduction

This dissertation presents results of a study of the role of the circulating registered nurse (CRN) in facilitating interprofessional relationships and communication in the operating room as well as surgical case length. As described in detail in the Background section, the CRN role evolved in conjunction with the history of medicine, surgery, and nursing in the US since the mid-19th century. In today's operating rooms, where surgery often involves use of sophisticated technologies, and where multiple professionals must interact with -and rely on – each other to bring each operation to a successful conclusion, the CRN plays a crucial role. The goal of the project was to describe the roles and relationships that communicate in the operating room and understand how these may also affect case length. Knowing who communicates was important but clarifying the effectiveness of communication patterns through the collection of survey data provided a lens into both effective and ineffective communication, and how that was affected by relationships. Finally, observations were done to visualize how relationships and communication took place during surgical procedures. From the observations came the creation of sociograms, visual models that show the dynamic interactions between the actors in the operating room, with the idea that this information could eventually be used to better comprehend how communication and relationships might impact patient outcomes and the time patients spend in the operating room.

The primary role of the CRN in maintaining a safe environment for patients during surgery is explicated below in the Significance section. Surgical errors occur at a very high rate and account for a high number of adverse events (T. L. Rodziewicz et al., 2021). In 1989 the U.S. Government created what is now known as the Agency for Healthcare Research and Quality (AHRQ). AHRQ reacted quickly and in 1999 published what is viewed by many as the first comprehensive guidebook to improving safety throughout healthcare in the U.S. *To Err is Human* (Kohn et al., 2000) helped change the way healthcare is delivered by looking at the process, not the people. *To Err is Human* offered practical suggestions on how to use relatively simple tools (checklists, process engineering and data collection) to improve everything from the admission department and into the surgical suite (Kohn et al., 2000). The implementation of these tools also improved efficiency in the operating room by eliminating waste and improving processes. One of those processes was the time the patient spent in the operating room. Referred to as case length duration, future studies found that shorter more efficiently orchestrated surgical cases lead to better patient outcomes and patient safety (Daley et al., 2015; Procter et al., 2010).

Communication is essential to minimizing errors (Forse et al., 2011). Effective communication is delivering messages to a target audience in a way that they are received and understood. In the operating room, a team of medical professionals gathers to provide care for surgical patients. What is unique about this "team" is that they function much more like a "crew" than that of a "team". Crews are a type of team that have evolved out of defined work processes that are consistently performed to complete a task. They are expert specialists with specific role positions that are closely synchronized with each other to perform the same work processes in varying environmental conditions (Sundstrom et al., 1990). The tasks that they perform are interdependent. For the sake of comparison, relate crews in the operating room to those flying a Boeing 737. Like an airline crew, where roles are fixed, e.g. pilot, first officer, etc. but the people performing those roles change constantly, roles in the operating room are fixed, e.g. surgeon, anesthesia provider, etc., but the people performing those roles may change from case to case.

In this study, the concept of relational coordination was employed to examine relationships and communication in the operating room. Relational coordination (RC), defined as a “mutually reinforcing process of interaction between communication and relationships carried out for the purpose of task integration” (Gittell et al., 2010, pp. 296-297), utilizes a framework that posits that relationships based on mutual respect, shared knowledge, and shared goals improve communication and problem solving in complex work environments. This construct of relational coordination has an emphasis on task integration and relationships. Research suggests that surgical teams that have positive relationships and communicate effectively produce higher-quality outcomes (Gittell, 2002; Leach et al., 2011). Relational coordination identifies specific dimensions of relationships integral to coordinating work, proposing that coordination occurs through frequent, high quality communication and well developed relationships (Gittell et al., 2010).

In addition, this dissertation study employed another tool to take a deeper dive into communication and relationships – namely social network analysis (SNA). Social networks are described as the formal and informal linkages among a defined set of individuals (Tichy et al., 1979). The linkages may be used to interpret the social behavior of the individuals involved (Tichy et al., 1979). The science of social network analysis emerged in the 1950’s when sociologists sought scientific ways to measure these linkages using mathematical techniques like graph theory and matrix algebra. A basic assumption of this approach is that beneath the complexity of relationships in the social network, there are recurring patterns of both connectedness and cleavage (Kilduff & Brass, 2010). Analysis of social networks brings a distinctive lens to the examination of organizational phenomena by examining individuals at the macro level (alliances, organizational reputation, network position) and the micro level (teams, power, trust, conflict, organizational citizenship behavior) (Kilduff & Brass, 2010). Social network analysis investigates how structural regularities influence individual behavior, and how the ties and absence of ties between those individuals may relate to an identified outcome (Otte & Rousseau, 2002). These two modalities, RC and SNA were used to provide important insights into the relationships, roles, communication, and their impact on case length and patient safety in the operating room.

Details of this mixed-methods study are presented fully in the Methods section. To assess pertinent aspects of relational coordination among members of the crew in the operating room, over 100 healthcare professionals at "The Hospital" were invited to take a survey, focusing on communications and relationships related to expected surgical case length duration. The second method involved directly observing ten scheduled surgeries at The Hospital, yielding over a thousand separate communications between members of the surgical crew. Data from those observations were analyzed using social network analysis. These analyses not only identified the members of the operating room crew by role, position, and prominence but also captured who was communicating and to whom the communication was directed. The resulting directed sociograms were very effective in observing the relationships and communications (Tubaro et al., 2016).

The last two sections of this dissertation present the results of the study and detailed discussions of the implications for practice, research, and education. In addition, there are sections on the limitations of the study and what might be recommendations for future research.

My interest in this research comes from over twenty years in administrative leadership in operating rooms, across the United States. I have worked in large academic medical centers, community hospitals and even a small for-profit hospital. What I have found in every one of these settings is confusion about the role of the CRN. Over the years the CRN role has been diminished by the distraction of new technologies, ever changing supplies and devices for complex surgeries, and lack of adequate staff to care for surgical patients. The CRN has assumed responsibility for most of these additional tasks and, by taking on these added management burdens, the CRN's primary role, i.e., to protect the patient on the operating room table, may be compromised. The impetus for this study was to shed some light on how critical the CRN role is in facilitating coordination and communication among the team members in the operating room, with the goal of promoting patient safety.

Chapter 2:

Background

Background

Contemporary Circulating Registered Nurses (CRNs) have a unique role in the operating room because they are not attached to the surgical field and because they can impact case length and surgical outcomes (Gillespie et al., 2012). The effectiveness of CRNs is measured by the strength with which they facilitate communication among members of the surgical team (Campbell Jr et al., 2008), and subsequentially lead to decreased case length and improved outcomes. The CRN is the conduit of communications that take place inside the surgical field with those who support the surgery functioning in roles outside of the field, both within the OR and outside, e.g., supply clerk, blood bank, equipment vendor, etc. The CRN role has emerged from a long history of registered nurse intervention on behalf of patient safety, infection control, and operating room functioning. Such history was shaped by many factors—historical, sociological, and economic.

Development of Operating Room Nursing

Circulating registered nurses deliver patient care primarily in operating rooms. The first CRN was employed in the United States in 1889 (Hamlin, 2020). Early operating rooms were generally described as horror chambers. They were often large theaters where many people gathered to watch the surgery, sometimes for entertainment. Instruments used in cases often belonged to the practicing surgeon and they were not sterilized between cases. It was not until 1867 when Joseph Lister pioneered the principles of aseptic surgery that things began to change. Lister used carbolic acid to treat wounds and adopted many of Louis Pasteur's principles of infection control to the operating room (Newsom, 2003).

Because of the conditions in early hospitals, many surgeons preferred doing surgery in homes. Present for surgery were the surgeon, and a nurse, and by the late 1800's, sometimes an anesthesiologist who administered ether as an anesthetic. In these early years, the nurse was to find appropriate furniture for the operating table; remove additional furniture and clutter from the room; scrub floors; set up the makeshift operating room table, draping it with rubber sheeting; set up another table for dressings; and damp mop the floor right before the case begins. Nurses also had additional roles such as washing the sponges that were used to absorb blood during the procedure, cleaning surgical instruments, and assisting in positioning the patient on the operating room table. The most important part of the nurse's job was to wash the sponges ahead of time and throughout the course of the surgery and hand them to the surgeon during surgery. Sponges were used in the surgical field to absorb blood during the procedure. During the case the nurse was often silent, engrossed in preparing sponges and frequently taking verbal abuse from both the surgeon and anesthesiologist (Lee, 1976; Murphy, 1995).

Florence Nightingale's work in the Crimean war was the beginning of what we know as modern nursing. When Nightingale arrived in Crimea in 1854, she found indescribably poor hygienic conditions and primitive medical practice, both on the battlefield and in the hospital (Barker, 1989). She and her nurses were called to help improve the hygienic conditions on the battlefield which led to decreased infections and mortality. Many basic medical supplies used for dressing wounds were in short supply or altogether absent during this war, and injured soldiers were crowded in small spaces, lying in their own human waste. Because of the lack of anesthetics, they could easily hear the screams from the soldier undergoing limb amputation ten feet away. The entire place was filthy.

There were no “operating rooms,” as we think of them today; surgery was performed on the battlefield or in makeshift tents in centralized locations. No one washed hands, performed aseptic preparation of the surgical site, or donned sterile attire prior to the case. Amputations, the most common surgical procedures during that conflict, were done on the battlefield as quickly as possible – in two to ten minutes – because of the absence of anesthesia. If, however, a soldier was fortunate enough to get to a medical facility, chloroform might be administered. Early modern nurses were just beginning to understand the importance of hygiene and sterility. Most cases during this time, like the amputations noted above, were much faster because there was no donning of sterile attire and often the patient would just die of blood loss or hypoxia (Stansbury et al., 2007).

Nursing in the US emerged as a profession during the Civil War and was initially provided by women from religious groups who had no training in nursing care. These women performed primarily domestic duties, literally cleaning up the messes of the physicians. The Civil War, as terrible and bloody as it was, provided the opportunity to shift nursing from primarily a domestic art to an important new profession for women. Florence Nightingale’s influence on nursing and nursing schools spread all the way across the ocean and into America. In 1873, “Nightingale schools” started to appear in prominent cities like Boston and Philadelphia, and her legacy of nursing education reform is apparent even today (Dolan, 1975; Glasper, 2020)

In the years between the end of the Civil War and the start of World War I, there were advances in anesthesia and surgical technique, and surgery moved out of the home and into the hospital (Schmitt, 1982). One of the major shifts that took place in the 1890’s was moving from antiseptic surgery to aseptic surgery. *Antiseptic* cleanliness means cleanliness sufficient to prevent microbial infections; microbes may still be present but are effectively neutralized. By contrast, *aseptic* cleanliness means that disease-causing microbes have been removed entirely; they are not present at all. Joseph Lister was a major proponent of antiseptic technique in the care of instrumentation and other devices used in surgery but unfortunately, the surgeons of that time were using these instruments without scrubbing hands and while wearing ordinary street clothes. It was German and Swiss surgeons who developed aseptic technique based on Koch's work with germ theory, and the United States was quick to follow with surgical attire changing to caps and gowns in 1883 (Nakayama, 2018). Nursing care quickly adopted the new germ theory, and it became a central focus of patient safety in the early 1900's. During this same period, surgeons began to see that surgical nurses could probably do more to facilitate successful surgical outcomes (Schmitt, 1982). Some nurses were beginning count instruments, prepare the patient before surgery, administer anesthetic agents, and assist the surgeon at the bedside.

Nursing continued to grow as a profession in the late 19^{th} and early 20^{th} centuries. By 1900 there were between 400 to 800 schools of nursing in the United States, most affiliated with hospitals, and by 1908, both the Army Nurse Corps and Navy Nurse Corps had been authorized by the US Congress (Salas, 2009) (History, 2001).

World War I has been characterized as the first big test of professional nursing and the newly established nurse corps (Trueland, 2017). When the war started in 1914, there were over twenty thousand nurses deployed from the United States alone. By this time, nurses had established themselves as professional members of the surgical team, valued for their knowledge and expertise. During the war, they were called upon to perform blood transfusions, and administer pain medications and anesthetics in hospital wards, nurses spent countless hours changing dressings and bedding (Jones, M.M., 2012). Their diligence led to a decrease in amputations and infections compared to the previous bloody Civil War (Jones, 2012). As nurses came home from the war, they began to have an expanded view of themselves, noting that they were part of a team of caregivers. They were becoming decision-makers in patient care (Hawes, 2016).

In the period between World War I (1914-1918) and World War II (1939-1945) nurses became better educated and more adequately trained, and there were significant advances in surgical technique and anesthetics. Surgeons no longer operated in large theaters as they learned more about the necessity of sterility in an operating room. Surgery also moved back into hospitals. Hospitals were evolving from places to house the infirm to places of science, new technology, and learning (Whelen, 2022).

The advances made in nursing came to a halt during the Great Depression. Many nursing schools closed and there was widespread unemployment. Wages were low for nurses, and many abandoned the profession altogether. The great depression marks one of the first recorded times that there was an actual nursing shortage. Healthcare institutions were baffled by the shortage, which came about with unprecedented speed and intensity (Whelen, 2022). With the advent of World War II, there became new interest in nursing as women sought ways to serve their country.

World War II saw more than 59,000 nurses serving in the Army Nurse Corps and 14,000 in the U.S. Navy. Nurses were practicing on the front lines, in field hospitals, hospital ships, and even planes and trains (Hawes, 2016). The Army and Navy nurse corps trained military nurses to administer IV fluids as well as perform basic nursing care; nurses also began to monitor the administration of antibiotics (Shoup, 1988). Their dedication to aseptic technique led to a post-injury mortality rate of less than four percent, a far cry from the greater than twenty-five percent mortality in the American Civil War (Hawes, 2016). Physicians in the field realized they needed greater assistance with surgical care and they turned to nurses for that assistance. The role of the CRN continued to develop during this period out of a necessity to standardize processes in the surgical field and facilitate communication in the hectic and frenetic culture of the field hospital. By the time the war ended, the nursing profession was better positioned than when the war began, and with improved salaries and opportunities it became a more attractive profession.

Despite that, after WWII, many nurses left the profession to return to domestic life and start families with the men returning from service. As a result, with the advent of the Korean War in 1950, there was a severe shortage of operating room nurses. To compensate for this shortage, many of the technical tasks in the operating room were allocated to what we know today as surgical technicians (Hallquist, 2005). Registered nurses in the operating room were now free from the surgical field and their focus shifted from the narrow surgical field to the wider perspective of the entire patient and surgical procedure. Circulating registered nurses were now wholly responsible for the nursing care of the surgical patient. This included preparing the patient for surgery, supporting patient care needs during the operation, understanding all aspects of the operation, providing supplies and support to those in the surgical field, and supervising unlicensed personnel (Hamlin, 2020; Lee, 1976), Mobile Army Surgical Hospitals (MASH units) evolved during the Korean War and registered nurses supervised the safety of patients and personnel there as well. Nurses functioned autonomously as part of the overall care team during the Korean War, independently administering antibiotics, triaging patients, and initiating blood transfusions (Hallquist, 2005).

Between the Korean and Vietnam wars (1950’s-1960’s) there were several advances in medical and surgical nursing. The lessons of the battlefield led to great advances in surgical care of trauma patients, and by the late 1950s and into the 1960s, nurses themselves began to recognize their unique roles and responsibilities in the operating room, especially with the introduction of complex surgeries such as solid organ transplantation and open-heart procedures (Brumm, 2004).

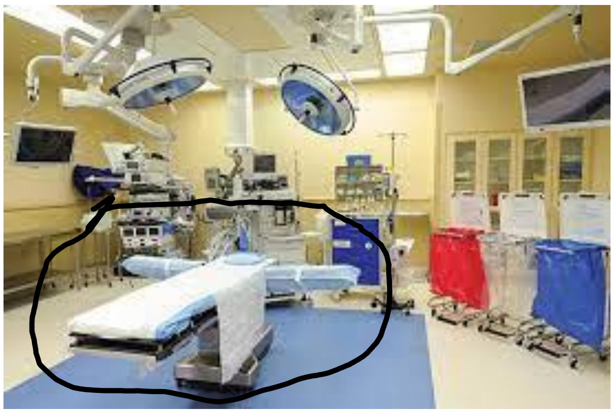
Despite advances achieved after WWII unacceptably high rates of death continued to occur in the operating room, much of which was attributed to poor surgical technique (Minuck, 1967). Operating room nurses were acutely aware of these issues, and in 1949 seventeen concerned operating room nurses gathered in New York City to review the state of their practice and identify ways they could contribute to improving patient outcomes. The result of this meeting was the formation of the Association of Operating Room Nurses (AORN) which now has a nationwide presence with over 275 chapters throughout the United States. The AORN began establishing standards for perioperative care, initially published in 1965. The standards focus on the operating room but recognizes the value and importance of nurses in other areas in perioperative services, e.g. pre-operative and post-operative care. Developed over time by operating room nursing leaders from all over the country and revised frequently to reflect updated evidence and evolving operating room nursing practice, these standards include planning, directing, and coordinating care in the operative suite, and supervising allied health personnel (surgical technicians, anesthesiology technicians, patient support personnel). The standards define the scope of operating room nursing practice and include role descriptions for CRNs, scrub nurses, and other nursing personnel, and recommended educational preparation for those roles (Shoup, 1988).

The Modern Operating Room

Modern operating rooms reflect the enormous technical advances in medicine and surgery that have occurred over the past 30 years. Highly skilled surgeons, nurses, and others employ sophisticated technologies and multiple medications to address a range of patient needs.

Figure 1

The modern operating room



To fully appreciate the roles and activities in operating rooms, it's important to understand the layout of a typical room (see Fig 1) and the "zones" in which various staff function. The surgery itself takes place in what is known as the "surgical field." The area inside the black circle is the area that includes the operating room table on which the patient is placed and all the tables, lights, equipment required to perform the actual procedure. Staff working within the surgical field "scrub in" for the case and wear special sterile attire. Personnel working within the surgical field include the surgeon and surgical technologist, who is responsible to prepare the instrumentation necessary for the case. There may also be surgical residents or fellows in training, or a scrub nurse who assists with aspects of the case. The surgical field is approximately the space inside of the black circle drawn in figure 1.

There are also people in critical roles who work outside of the surgical field. These individuals wear surgically clean, but not sterile attire. These include the anesthesia provider, equipment technicians, and other specialists as needed; CRNs also work outside the sterile field, and they have a unique position on the surgical team. They interact frequently with other members of the surgical team and often provide oversight for other departments that interface with the operating room, such as blood bank, sterile processing, information technology, and equipment and supply vendors who may be present. The CRNs' ability to effectively communicate with all members of the surgical team significantly impacts the quality of care, efficiency, and outcome of the surgical case (Mills et al., 2008). Patient safety and infection control are also primary responsibilities for modern CRNs (Alfredsdottir & Bjornsdottir, 2008). CRNs are responsible for maintaining sterility, overseeing staff involved in the surgical case, and having a complete understanding of how the surgery was progressing. While others in the operating room are completely focused on the technical aspects of the surgery and the patient's responses, CRNs are constantly scanning the room, and their global perspective is critical to the overall safety and security of the patient and staff. The burden on CRNs is significant. They must balance high physical demands, instinct, and an overwhelming commitment to patient safety with all the ongoing demands of the surgical field. For example, those focused solely on the patient may not see a surgical drape catch on fire, or a surgical light that drifts because the fixture has become loose, or a member of the team who accidently breaks sterile technique, thus potentially introducing additional risks to patients; it is the CRNs who notice these kinds of issues and alert the rest of the team.

Many of the activities in the operating room generate noise and distractions, making the job of the CRN complex and difficult, demanding a high level of focus and mental acuity to remain vigilant for safety issues and potential problems that may arise ("AORN Position Statement on Perioperative Registered Nurse Circulator Dedicated to Every Patient Undergoing an Operative or Other Invasive Procedure," 2019). With every surgical improvement comes changes in equipment, instrumentation, and technique. Circulating registered nurses must be knowledgeable about a wide variety of surgeries to recognize and respond appropriately to unexpected – and potentially dangerous – changes in conditions both inside and outside the surgical field.

Helping the surgery proceed as scheduled is a critical role for CRNs. There is clear evidence that increases in surgery time can lead to adverse outcomes for patients (Daley et al., 2015; Procter et al., 2010). For the purposes of this paper, operating room time (case length duration) is defined as the time that the scalpel touches the patient skin to the time that the surgeon steps out of the surgical field and removes surgical attire. Circulating registered nurses assist in keeping surgery on time by making sure the patient arrives to the OR on time; is efficiently prepared and draped with sterile drapes; and that all supplies are ready and available to the surgeon. By having good relationships with support personnel inside and outside of the operating room, CRNs become highly efficient and effective in obtaining ancillary services frequently required for many surgeries, such as the acquisition of blood products and lab reagents.

It is because of their central role in the smooth functioning of the operating room and ensuring a safe environment for patients and staff that this dissertation focuses on the role of the CRN in facilitating communication and maintaining relationships in the operating room and describes how these attributes may contribute to improved efficiency and reduced risks of surgical complications.

Chapter 3:

Significance

Significance

The Patient Safety Movement

To fully appreciate the real and potential contributions of CRNs in keeping patients safe during surgery, it’s helpful to understand the larger context of the patient safety movement. In 1999, the Institute of Medicine (now the National Academy of Medicine) published what turned out to be a singularly critical treatise on the magnitude of injuries and deaths associated with medical errors, especially in the operating room (Institute of Medicine Committee on Quality of Health Care in, 2000). The report indicated that medical errors were occurring at alarming rates, many of them involving surgical procedures. The operating room was identified as a place where high error rates occur often with serious consequences (Institute of Medicine Committee on Quality of Health Care in, 2000). Among the recommendations in the report was the need to improve teamwork and standardize processes. Throughout healthcare organizations in the early 2000’s, doctors, nurses, surgical technicians, and anesthesiologists were being brought together to work and think in ways unfamiliar to the traditional hierarchical models that had been common in operating rooms (Walton, 2006). Leaders recognized quickly that barriers existed in communication and standardization, and that historical boundaries (many due to social and structural hierarchies) prevented some team members from participating equally and from being heard. In high-risk situations such as operating rooms, those rigid hierarchical structures could have serious detrimental effects on patient safety and outcomes (Walton, 2006).

The necessity of effective communication in high-risk areas is well documented and discussed throughout medical literature (Frasier et al., 2019; Osborne-Smith & Kyle Hodgen, 2017; Tørring et al., 2019). Frasier et al. explored the relationship between familiarity and effective communication. Performing a purposive sample of ten operations, communication events were documented using a video camera and forty- eight hours of video were analyzed. Familiarity scores were assigned to dyads of communication among team members, and it was learned that familiarity was, in fact, not associated with communication. This exploratory study by Frasier et al. provided some insight into communication in the operating room, but it did not support the supposition that team members need to be familiar with each other to communicate well. Osborne-Smith (2017) examined current approaches to effective communication in the operating room (e.g., teamwork exercises, checklists, minimizing distractions), and found that while these tools were well-developed, they were implemented inconsistently. Finally, Toerring, Gittell, and others, studied 39 surgical teams within the framework of relational coordination, evaluating team communication and relationship dynamics. This well-designed ethnography determined that mutual respect, a foundation for trust and relationship building, was lacking in the operative settings included in their study.

Hospital personnel formally communicate in several formats. For example, in many intensive care units and emergency rooms, doctors and nurses participate in daily rounds, during which team members discuss patients' conditions and the plans for the day. Having specialized nurses in intensive care units participating and often leading such patient rounds (as a key communication hub) leads to better patient outcomes, better teamwork, and improved communication (Durbin Jr, 2006). However, the situation is very different in the operating room. Operating rooms are traditionally based on a hierarchical model with the surgeon identified as "the captain of the ship". There have been several recommendations for breaking down the traditional hierarchies such as this, moving more towards a team approach, and including the use of checklists and team training that would teach members of the team to quickly identify potential issues before they cause any safety mishaps that could harm the patient (Gawande, 2007; Haynes et al., 2009; Lingard et al., 2008; Osborne-Smith & Kyle Hodgen, 2017). Adapting these checklists and tools to the OR environment seemed like an effective way to reduce procedural errors. For example, at the completion of a large multi-site study implementing checklists across many settings, (Haynes, et al., 2009), there was significant improvement in both morbidity and mortality. The rate of death was 1.5% before the checklist was introduced and declined to 0.8% afterward (P=0.003). Inpatient complications occurred in 11.0% of patients at baseline and in 7.0% after introduction of the checklist (P<0.001) (Haynes et al., 2009). However, while initial results of implementing checklists looked promising (Haynes et al., 2009; Papadakis et al., 2019), surgical errors have continued to occur at unacceptable rates (Haynes et al., 2009; Papadakis et al., 2019).

The National Quality Forum, a not-for-profit organization that works to catalyze improvements in healthcare, has also worked to prevent surgical errors and deaths, focusing particularly on preventing "seriously reportable events," known colloquially as "Never Events." These events are: a) surgery or other invasive procedure performed on the wrong site; e.g., amputation of a left limb (incorrect surgical site) instead of the right limb (correct site); b) surgery or other invasive procedure performed on the wrong patient, c) wrong surgical or other invasive procedure performed on a patient; d) unintended retention of a foreign object, e.g., a surgical sponge, in a patient after surgery or other invasive procedure; e) intraoperative or immediately postoperative/post-procedure death in a low-risk patient (as defined by the American College of Surgeons and the American Society of Anesthesiologists).

In 2004, prior to the introduction of checklists, the Joint Commission[1] introduced a standardized procedure known as the Universal Protocol to decrease the incidence of wrong site

[1] The Joint Commission is an independent non-profit agency charged with driving quality improvement and patient safety in healthcare.

surgery (Norton, 2007; Saufl, 2004). The Universal Protocol was developed as a part of a group of National Patient Safety Goals (NPSG) developed by the Joint Commission to improve safety throughout healthcare institutions. The Universal Protocol specifies three minimum requirements: verifying the patient is correct, marking the correct surgical site, and performing a time-out immediately prior to the first incision in the operating room (Kwaan et al., 2006). The time-out requires that all members of the surgical team be present and actively communicating with each other to agree upon correct patient identity, correct surgical site, and confirmation of the procedure to be done. In many hospitals, it is the CRN who leads the time out. Although initial studies on the effectiveness of the time-out procedure demonstrated significant reductions in errors (Haynes et al., 2009), these impressive results have not been sustained (Rydenfält et al., 2013; Weinger, 2021) One of the reasons for this reduction has been lack of compliance; in one study, for example, checklists were only completed 10% of the time (Rydenfält et al., 2013). Despite these challenges, however, elements of the Universal Protocol are now standard of practice prior to starting any invasive procedures that occur in healthcare institutions (Stahel et al., 2009).

Surgical Errors Persist

Despite widespread implementation of the Universal Protocol, use of surgical checklists, and team training programs, wrong site surgery events continue to occur, and the incidence of surgical errors continues to rise. It is estimated that of over 200 million surgeries performed each year in the US there are an approximately 4000 surgical errors and that of the 4000, 6.6% were mortalities (Mehtsun et al., 2013). Many experts believe that failures of Universal Protocol to reduce these numbers lies in the ineffective execution and monitoring of performance within procedural areas (Haynes et al., 2009; Henriksen et al., 2008; Lingard et al., 2008; Salas et al., 2009; Salas et al., 2008; Weaver et al., 2010; Young-Xu et al., 2011).

Realizing that the Universal Protocol was not, in itself, the solution to the problem of continuing surgical errors, health care organizations and patient safety experts looked at organizational factors, primarily focusing on team functioning, that might provide potential solutions (Aguinis & Kraiger, 2009; Grogan et al., 2004; Mathieu et al., 2008). Like other high-risk industries, personnel in the operating room work in teams, defined as distinguishable sets of two or more individuals who interact dynamically, adaptively, and interdependently to perform specific roles or functions for a common goal or purpose (Dyer, 1984; Salas et al., 1992; Webber & Klimoski, 2004). Teams are not just groups of individuals working together; rather, teams share leadership roles, mutual accountability for a common goal, and they encourage open-ended discussions to meet performance targets. Specialized team training has been shown to decrease errors, improve communication, and standardize work processes in high-risk areas like the operating room (Armour Forse et al., 2011)

Over time, the team members develop relationships that lead to distinctive types of communication and work processes Developing an effective team requires more than just improving communication and standardizing work processes: it requires an understanding of the relationships that exist within the work environment (Gittell, 2002). Teams are dependent on the knowledge of each participant’s contribution to the overall work process, and they rely on task interdependence (an understanding of who needs to know what, why, and with what degree of urgency) to achieve goals and objectives (Gittell, 2006; Lindbeck & Snower, 2000; Wageman et al., 2005). Work process and task integration improve when work relationships (shared goals, shared knowledge, mutual respect) are understood and supported by the people who perform the interdependent tasks (Gittell et al., 2010).To summarize, to be maximally effective, teams must work to develop intimate relationships that can positively affect outcomes in the work environment (Laflamme et al., 2019).

Operating room crews have unique properties, however, that may contribute to difficulties in achieving some of the hallmarks of relationships and communications described above. First, while the roles in operating room are relatively stable, the individuals in those roles change from procedure to procedure; this makes the staff function more as a crew than a classic team. Second, it's not just the professional team members who change, but each patient is different, adding another dimension of uncertainty to the environment; two patients undergoing the same procedures with the same OR staff may have vastly different responses, necessitating vastly different responses from the staff. To gain a better understanding of why the Universal Protocol and team training exercises have not resolved the issue of reducing surgical errors in this complex environment, it is time to step back and take a fresh look at the role of the CRN and see how and where the role fits into the complex web of communication and relationships in the operating room.

Conceptual Framework

The conceptual framework guiding this study is the widely-accepted framework for quality assessment proposed by Avedis Donabedian, MD, MPH in 1988 (Donabedian, 1988). Dr. Donabedian was a pioneer in assessing medical errors and quality, and his work has been studied and adapted widely to throughout healthcare. The key components of Donabedian's model include structure, process, and outcome.

Structure

Structure refers to the attributes of the care setting (Donabedian, 1988). It includes all of the things that are necessary to deliver safe quality care. Perhaps the most important element of structure is human capital - people. In the operating room, members of a general surgery crew comprise the structure of interest for this study.

Process

Process refers to what is done in giving and receiving care (Donabedian, 1988). In this study, the processes of interest are communication and relationships, specifically the patterns of communication and workflow interdependencies. These patterns were described using tools for measuring relational coordination and social networks in the operating room.

Relational coordination

The theory of relational coordination identifies specific dimensions of relationships integral to the coordination of work, and proposes that coordination occurs through frequent, high quality communication, supported by relationships of shared goals, shared knowledge, and mutual respect (Gittell et al., 2010). Relational coordination is defined as "mutually reinforcing process of interaction between communication and relationships carried out for the purpose of task integration"(Gittell, 2006). Relational coordination has been used as a theoretical/conceptual model in studies related to integrated care delivery (Havens et al., 2010), inpatient units (Gittell et al., 2000), patient perceptions of health care delivery (Havens et al., 2010), and even for a recent study on operating rooms (Tørring et al., 2019).

Social network analysis

Formal and informal social interactions that characterize relationships create networks characterized by specific linkages and social ties among a defined set of individuals or actors;

these linkages can be used to interpret the social behavior of the individuals involved. (Tichy et al., 1979) Analysis of social networks brings a distinctive view of organizational phenomena by examining individuals at the macro level (alliances, organizational reputation network governance) and the micro level (teams, power, trust, conflict, organizational citizenship behavior. This study focuses on the micro level of the operating room.

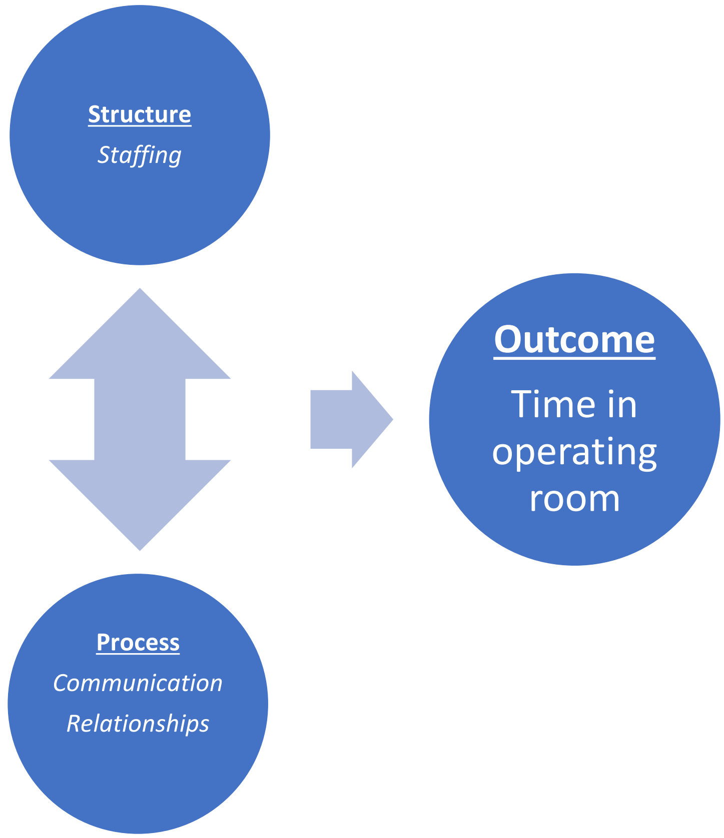
Outcomes

Donabedian defines outcomes as the effect of care on health status (Donabedian, 1988). While patient outcomes were not directly captured as part of this study, the outcome of interest in this study is *case length duration.* This outcome was chosen because research clearly demonstrates that the longer patients spend in the operating room, the greater the risk for preventable complications such as deep vein thrombosis, pulmonary embolism, and surgical site infection (Cheng et al., 2018; Daley et al., 2015; Wolf et al., 2010)

Figure 2, below, illustrates how this model is being used in this study.

Figure 2

Conceptual Framework



Modified from Donabedian Quality Model (1966)

Specific AIMS

This study investigated the role of the circulating registered nurse as it pertains to communication and relationships, and the association with the overall length of time the patient spent in the operating room.

The specific aims of this study are:

AIM 1-Describe communication and relationship patterns within operating room teams.

RQ- What are the relationships in the operating room?

RQ- Who is part of the operating room team?

RQ- What are the types and amounts of communication in an operating room.

AIM 2- Describe the CRN’s role within the social network of the operating room and their role’s relationship to overall case length.

Chapter 4:

Research Methods

Research Methods

Design

This is a mixed methods, descriptive, exploratory study of relationships and communications among surgical crew members, employing the tools of relational coordination and social network analysis to describe these relationships and patterns of communications and their association with surgical case length duration. This study received expedited approval by Emory University's Institutional Review Board. Of note, the IRB determined that human subjects review for patients undergoing the observed surgeries was not required for this study.

Setting

The setting was operating rooms at a university-affiliated, tertiary care hospital in the metropolitan Atlanta area; hereinafter referred to as The Hospital. When compared to other community teaching facilities around the country, The Hospital cares for highly acute patients. The Hospital has 17 active operating rooms with 324 certified inpatient beds. Potential surgical team participants were recruited at staff meetings and through posted flyers. Additional information was sent by email to staff and physicians working on general surgery teams. Permission to attend meetings and recruit staff was obtained from chiefs of surgery and anesthesia at The Hospital, the Director of Surgical Services, and the Nursing Research Committee.

Some of the most complex patients cared for at The Hospital are those who undergo general surgery. General surgery is a discipline that covers a broad spectrum of procedures, primarily focused on the abdominal contents. At The Hospital, general surgery cases include hundreds of different procedure types. For the purposes of this study, the focus was on five general surgery procedures that are performed frequently at The Hospital:

- Laparoscopic Cholecystectomy (lap choly)
- Exploratory laparoscopy
- Thyroidectomy/Parathyroidectomy- although none were observed during the study
- Appendectomy
- Whipple (pancreaticoduodenectomy)

Sample

Relational Coordination

Relational coordination (RC) among surgeons and staff was assessed using a survey specially adapted for this study (details below). The RC survey was sent to 120 operating room personnel, including 25 registered nurses; 25 surgical technicians; 30 surgeons in private practice; 11 Emory surgical faculty; 12 surgical residents (when no residents were present, qualified technicians or nurses from the OR staff served as first assistants); and eight support staff such as nurses' aides and anesthesia technicians. The only criterion for eligibility was that individuals were actively assigned to work on general surgery cases.

Social Network Observations

Data for analyzing the social networks in the operating room were collected during direct observation of ten surgical cases (details below). Recommendations regarding sample sizes in studies using social network analysis vary (Bullen, 2021; Conroy, 2018; Lwanga et al., 1991) with at least one study (Lwanga et al., 1991) recommending that the number of observations equal approximately ten percent of the total population observed. This proved impractical for the phenomenon under study. Given the exploratory nature of this study, as well as the challenges inherent in the observations, the initial plan was to observe communications during ten surgical cases, with the option to observe more if no clear patterns emerged from the initial sample. The final sample of 10 observed cases, of which nine were used in the analysis, proved sufficient.

Measurement

Relational Coordination

The Relational Coordination (RC) Survey is an instrument that enables an understanding of where relationships are strongest and weakest and how those relationships facilitate improved communication among team members (Gittell, 2006). The survey is flexible and dynamic; it can be used as a stand-alone instrument or integrated into another methodology. In this study, the RC survey results were integrated with results from the social network analysis to address the research aims.

Relational coordination was measured using the Relational Coordination (RC) Survey, a seven-question, 5-point Likert scale that focuses on the dimensions of relational coordination (Gittell et al., 2010). It is considered a valid and reliable instrument that is well documented throughout sociological and health services (Gilmartin et al., 2015; Gittell, 2006; Gittell et al., 2010) but few studies have taken place in operating rooms, and none have focused on the role of the circulating registered nurse or the impact of relationships and communication among surgical team members to the time spent in the operating room (surgical case length).

The RC questions are broken into two categories: four dimensions of communication (frequency, timeliness, accuracy, and respect), and three dimensions of relationship (shared goals, shared knowledge, and mutual respect); see Appendix 1 for a copy of the complete survey. In 2015, a group of infection preventionists tested the RC Survey for reliability and validity. Their study looked at 4 different groups of providers (MD, RN, Environmental Services, Hospital Administration). They reported a Cronbach's alpha of .91. Factor analyses confirmed a

4-factor solution that explained 58.17% of the variance (Gilmartin et al., 2015). Other studies in health care settings reported reliability using Cronbach's alpha ranging from .899 to .91 (Gittell et al., 2000; Havens et al., 2010).

Observations

Social Network Analysis (SNA)

The evolution of social network analysis dates to a landmark study by Jacob Moreno and Helen Jennings at the Hudson School for Girls. Social Network scientists were trying to solve the problem mathematically of how group members interacted with each other. Jennings mapped a social network of runaway girls using "sociometry," a technique that graphically represents how individuals feel about each other {Borgatti, 2009). Moreno's work is foundational to the development of network theory; he effectively created the model to describe the abstract nature of relationship (Moreno, 1941).

As the years progressed the complexity behind the science of network analysis also expanded. Graph theory and matrix algebra were used to refine the model created by Moreno, and scientists from the Massachusetts Institute of Technology (MIT) began employing laboratory science to evaluate the effectiveness of network analysis (Moreno, 1941). These MIT scientists were performing experiments in a laboratory setting with strict controls and precision. Sociologists have also used network analysis to represent the structure of communities (Wellman, 1983). Borgatti, et al. (2009) reviewed the development of SNA as a tool for analyzing community network structures in the fields of anthropology, sociology, and a host of other social sciences. In fact, by the 1990's, social network models were being explored in physics, biology, and several applied fields such as management consulting, public health, and crime fighting (Otte & Rousseau, 2002).

Interestingly, national security is an area that has most embraced network analysis (Borgatti et al., 2009). It has been suggested that terrorist groups and even Saddam Hussein were captured using the principles of network analysis (Borgatti et al., 2009). The methodology of SNA has also contributed to the formulation of quantitative measures of many qualitative concepts that have long been in use in the study of society (Adhikari, 1960).

Procedures

Relational Coordination Survey (RC Survey)

The RC survey was distributed to the 120 eligible operating room staff and physicians in electronic form (Monkey, 2020). Eligible staff included those who actively participated in general surgery cases. An email was sent to each potential participant with instructions on how to access and complete the survey; proceeding from the instructions to the survey was considered evidence of consent to participate. Access to the survey was kept open for six months with reminder emails sent to staff every month. In total there were 34 responses (described below). This represents a 28% response rate. Data from the surveys were then downloaded into the SPSS statistical software format for analysis.

Direct observations of social networks

Operating room schedules were reviewed the day before scheduled observations to identify general surgery cases that met the inclusion criteria described below. General surgery cases were chosen because they occur in almost every operating room in the United States, and individual staff tend to vary considerably from case to case, whereas in specialties such as cardiac surgery, individual team members become highly specialized, with little variation in the composition of the team from case to case. Specialized teams do not possess the essential “crew” characteristics of interest to this study. As described previously, most operating room *teams* are actually *crews* in that the individuals who fill each professional role vary considerably from case to case; their composition is fluid and the equipment and supplies used vary in much greater degree with surgery cases than with a specialized team. Finally, to be included in the study, all staff assigned to the surgical case had to agree to be observed.

In total, ten surgeries were observed. One of the surgeries had to be aborted due to malfunctioning equipment so only nine were included in the analytic sample. Staff were recruited based on their daily work assignments. The staff members involved in the surgical cases selected for observation were approached either the day before surgery or on the morning/afternoon of the case and reminded of the purposes of the research and the procedures involved. It was emphasized that only interactions and communications were observed, and that this was not a regulatory exercise or review of clinical practice. Staff were provided with a description of risks and benefits associated with participation, offered a chance to ask questions, and reminded that their decision to participate or not participate would have no effect on their employment at The Hospital in any way. If all team members for that planned surgery agreed to be observed then the surgery was observed; if any single member of the team declined to participate, then that surgical case was not included. Only two travel nurses declined to be observed; the remaining teams were very supportive and engaged.

The space, team members, roles, case type and case length duration were observed and recorded. Field notes were developed to document communications – both formal and informal – as they took place between team members. A coding system was created to document who communicated to whom and whether the communication was verbal or nonverbal.

Because of the fast pace of interactions in an operating room, the QuickTapSurvey application {Formstack, 2010) was selected to assist with data collection. The QuickTapSurvey was selected because of its adaptability, simplicity, and ability to download data directly into Microsoft Excel (2016). In addition, it was easy to load both verbal and nonverbal cues and to include space to document other things about the case. The collected data were all downloaded before the end of each case. A sample of the QuickTapSurvey is in Appendix 2.

The app allowed the investigator to record each interaction, both formal and casual, between any two or more crew members. For example, the user might note the time of an interaction, the type, the content, and the response, all with simple screen taps. Each tap was coded into a data point, and at the conclusion of the case, the data were downloaded into Microsoft Excel (2016) where it was sorted and cleaned before input into the Gephi (Bastian et al., 2009) software to complete the social network analysis.

Statistical Analysis

Relational coordination

The Survey Monkey© data were exported to SPSS (IBM, 2017) analysis. All data were reviewed for completeness prior to analysis. Descriptive statistics (mean and standard deviation or median and IQR (interquartile range)) were computed for continuous and ordinal measures along with frequencies and percentages for each item's response in the relational coordination survey. Statistical analyses were completed using SPSS v.27.0 [REF: IBM 2020].

Social Network Analysis

All the communication observations were recorded and then downloaded as CSV files and imported into Microsoft Excel (2016) files. After cleaning and organizing the detailed communications data for each of the ten surgeries, these data were then imported into the open source network analysis software, Gephi (Bastian et al., 2009). The Gephi network analysis software generated both graphical representations of the networks, i.e., sociograms, as well as statistical analysis metrics for the network such as “graph density” and “average clustering” plus node-level metrics for each surgical crew member’s role such as “betweenness,” “centrality,” “authority,” and “hub”. These analyses were completed using the over 1100 communications observed over the nine surgeries in the analytic sample.

Due to the small number of complete surgeries (nine) and the ordinal nature of many of the social network graph metrics, Spearman’s rho, ρ, (non-parametric) correlations were computed for each network graph SNA statistics and for each role’s (node-level) SNA metrics against the surgical case duration (in minutes). Those metrics with correlations of 0.5 and higher (or -0.5 and lower) were noted for large correlations ($\rho > 0.5$ or $\rho < -0.5$) (large effect sizes are for correlations with an absolute value > 0.5, (Cohen, 1988). From these detailed observations, patterns of communication, prominence of the actors (roles or nodes), and relationship ties all began to emerge and show alignment with the network statistics defined in Appendix 3.

Chapter 5:

Results

Results

This section reports the results of both components of the overall study, i.e. the Relational Coordination survey and the Social Network Analysis. The next section, Discussion, synthesizes these results to address the research aims and associated questions.

AIM 1- **Des**cribe and analyze patterns of communication and relationships within operating room teams

RQ- What are the relationships in the operating room?

RQ- Who is part of the operating room team

RQ- Describe communication in an operating room

AIM 2- Describe the CRN's role within the social network of the operating room and their role's relationship to overall case length.

Relational Coordination

To address the research questions about relationships and communication in the OR for Aim 1, the results from the Relational Coordination (RC) survey are summarized here. The modified seven-question Relational Coordination (RC) survey was sent to 120 operating room staff and physicians. 34 people responded, for a response rate of 28.3%. The demographics for these 34 individuals are presented in Table 1. The choice of metrics and statistical tests were explained previously in the methods section.

Thirty-four healthcare workers completed the survey. The majority (73.6%) were 25-45 years old, female (50%), and were white (82.4%) (Table 1). The survey was mostly completed by CRNA's (58.8%) and Anesthesiologists (32.4%). Only 1 nurse (2.9%) completed the RC survey. A plurality (44.1%) had 5 years or fewer at the hospital and the majority (55.9%) had worked 0-10 years in the operating room.

Table 1

Demographics

Characteristic	Category	Frequency	Percent
Role	Surgeon	1	2.9%
	Nurse	1	2.9%
	Anesthesiologist	11	32.4%
	CRNA	20	58.8%
	Anesthesia Technician	1	2.9%
Gender	Male	16	47.1%
	Female	17	50.0%
	Transgender	1	2.9%
Race	White/Caucasian	28	82.4%
	Asian	4	11.8%
	Other Race (no response)	2	5.8%
Age	15-35*	15	44.1%
	35-45	11	32.4%
	45 and older	8	23.5%
Time at hospital	0-5 yr	15	44.1%
	5-10 yr	4	11.8%
	10-15 yr	6	17.6%
	15-20 yr	3	8.8%
	20-25 yr	4	11.8%
	>25 yr	2	5.9%
Time in OR	0-5 yr	10	29.4%
	5-10 yr	9	26.5%
	10-15 yr	5	14.7%
	15-20 yr	3	8.8%
	20-25 yr	5	14.7%
	>25 yr	2	5.9%

**** Note: the demographics form used 10-year increments to capture age, however none of the employed surgical staff was under the age of 18.***

The seven Relational Coordination survey questions had response levels ranging from 1, to 5, where 1 is generally the lowest or least desirable level, e.g. communication is never timely enough and 5 the most desirable level, e.g. always communicate in a timely manner. The only exception was the first item, frequency of communication, where a mid-score of 3 indicated “just the right amount”, levels 1 and 2 indicating too little communication and of 4 and 5 indicating too much communication. All seven items were asked in relation to case duration or keeping surgical cases running on time (see Appendix 1 for the exact wording of all RC items). For these 34 respondents, the Cronbach’s alpha for these 7 RC items was $\alpha = 0.88$.

As can be seen in Table 2 and Figure 3, 50% or more of the respondents expressed dissatisfaction with five dimensions of the RC survey: the frequency, accuracy, and problem-solving focus of communications relating to case length duration, as well as a poorer sense of shared knowledge and mutual respect for the professional contributions respondents made to keeping cases running on time. For the remaining items, i.e., timeliness of communications and shared goals of keeping cases running on time, over 38% of respondents expressed dissatisfaction. Respondents clearly indicated a need for more frequent and accurate communication regarding expected case length; communication more focused on problem-solving than laying blame; a greater sense of shared knowledge about the progress of the case, and greater respect for the contributions of different professionals in the operating room.

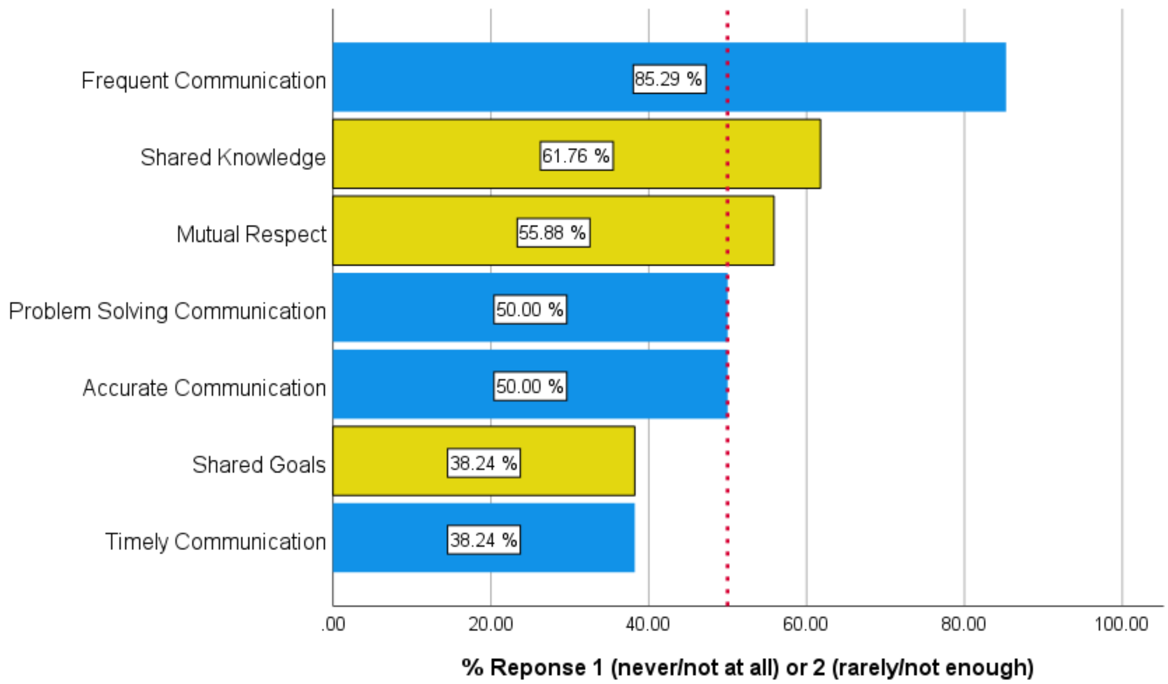
Table 2

Relational coordination survey responses summary (n=34)

Relational Coordination Item	Response Code and Descriptions 1	2	3	4	5
Frequent Communication	Not Nearly Enough	Not Enough	Just the Right Amount	Too Often	Much Too Often
	12	17	5	0	0
Timely Communication	Never	Rarely	Occasionally	Often	Always
	1	12	19	2	0
Accurate Communication	Never	Rarely	Occasionally	Often	Always
	1	16	16	1	0
Problem Solving Communication	Always Blame	Mostly Blame	Neither Blame Or solve	Most Solve	Always Solve
	1	16	13	4	0
Shared Goals	Not at All	A Little	Somewhat	A Lot	Completely
	2	11	15	6	0
Shared Knowledge	Nothing	A Little	Some	A Lot	Everything
	7	14	9	4	0
Mutual Respect	Not at All	A Little	Somewhat	A Lot	Completely
	3	16	10	4	1

Figure 3

Relational Coordination Items – Percent of responses < 3 undesirable responses)



Social Network Analysis

To further address the research questions of relationships and communication in the OR for Aim 1 as well as describing who is part of the operating room crew, and describing the CRN's role within the social network of the operating room as related to case length (Aim 2), the results of the social network analyses are summarized here.

Ten general surgery cases were observed at The Hospital. As noted previously, one case (# 7) was removed prior to analysis due to the short duration; it was ended after nine minutes for technical reasons. Observations of the nine completed surgeries yielded 1131 separate communications between team members. As noted in Methods, sociograms and SNA metrics were generated for each of these nine surgeries; these are presented below, followed by a more comprehensive review and summary of findings in the Discussion chapter.

Table 3 provides a summary of the ten surgeries observed. For the nine cases included in the analysis, case length ranged from 32 to 156 minutes (median 73 min), and there were between 52 and 271 separate communications recorded (median 98 communications per surgery). The pace of communications varied during the surgery, but on average the rate of communication ranged from 0.72 to 2.67 communications per minute during surgery (with a median of 1.72 communications per minute). It is worth noting that in general, longer surgeries had more observed communications, but not always. Surgery one was 59 min long with 127 observed communications whereas surgery ten was almost twice a long at 102 min with much lower communications of 73 observed.

The number of people in the OR (surgical crew members) were counted as individual roles or *nodes* for each surgery. The number of nodes per case ranged from five to 12 (median eight). Overall, there were 18 different roles observed across the nine surgeries listed in Table 4. Five of these roles were observed in all nine surgeries: anesthesiologist, circulating nurse, surgeon, surgical assistant, and surgical tech. The next two most often observed roles were the surgical resident (observed in eight of nine) and certified registered nurse anesthetist (CRNA) and anesthesia assistant (AA) (observed in six of nine). The remaining 11 roles were observed in less than half (four or fewer) of the nine surgeries including: student nurse, nurse tech, medical student, outside RN, blood bank, charge nurse, nurse relief, patient family, supply chain, vendor or other. The last column in Table 4 presents the number of unique *edges* or source-to-target pairs for the communications observed during each surgery.

Table 3

Observation time and number of communications observed

Case	Begin	End	Duration (min)	Number of Communications	Procedure	Nodes (roles)	Edges (unique or 1 edge)
1	7:30 AM	8:29 AM	59	127	Lap Chole	12	34
2	7:52 AM	9:15 AM	83	177	Lap Chole	11	24
3	9:20 AM	10:21 AM	61	83	Appendectomy	7	15
4	8:10 AM	10:46 AM	156	271	Whipple	11	39
5	10:47 AM	11:38 AM	51	52	Laparoscopy	8	12
6	10:53 AM	12:06 PM	73	195	Lap Chole	10	35
7	10:54 AM	11:03 AM	9	5	Case Aborted*	5	5
8	7:32 AM	8:04 AM	32	55	Lap Chole	8	18
9	12:13 PM	1:54 PM	101	98	Lap Chole	7	30
10	3:06 PM	4:48 PM	102	73	Laparoscopy	5	18

*Case Aborted = surgery canceled for technical reasons; Lap Chole = laparoscopic cholecystectomy

Each communication captured three pieces of information: the two people involved in the communication and the direction which identified the source (person/role initiating the communication) and the target (person/role receiving the communication). These three pieces of information allowed for a directed social network analysis to be accomplished. Table 4 provides a summary of the observed communications between the source-to-target pairs that were either initiated by the surgeon or CRN or received by them. The first three columns of source-to-target pairs highlights the unique communication pairs where either the surgeon or the circulating nurse was the source whereas the last 3 columns show highlights for the unique communication pairs where either the surgeon or circulating nurse were the target of the communication. The top seven source-to-target pairs involved communications from either the surgeon or the circulating nurse (CRN) comprising 584/1131 = 51.6% of all communications observed over the nine surgeries. Considering them in their source role, surgeons initiated 541 communications (47.8%) and CRNs initiated 316 (27.9%) of the communications. The surgeon and CRN were the target less often but surgeons received 160 (14.1%) of the communications and CRNs received 142 (12.6%) of the communications.

Table 4

Directed Communications: Unique Source to Target Pairs

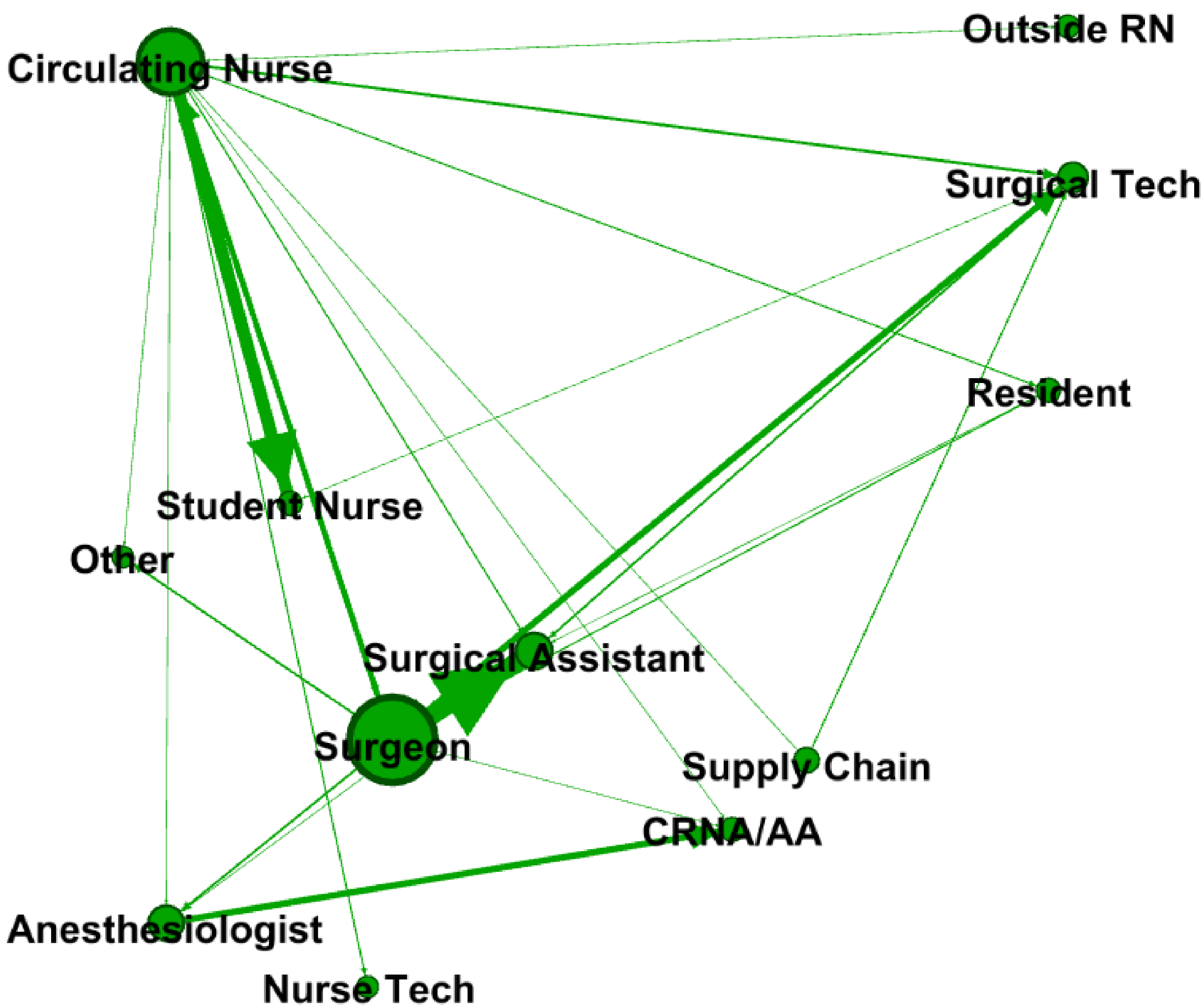
"Surg to" (from surgeon as source) / "CRN to" (from CRN as source)			"to Surg" (surgeon as target) / "to CRN" (CRN as target)		
Source to Target	Frequency	Percent	Source to Target	Frequency	Percent
Surg to Anes	130	11.5	Surg to CRN	76	6.7
Surg to SA	103	9.1	CRN to Surg	71	6.3
Surg to Res	94	8.3	SA to Surg	67	5.9
Surg to CRN	76	6.7	Tech to CRN	43	3.8
CRN to Surg	71	6.3	Tech to Surg	25	2.2
CRN to ST	67	5.9	12 to Surg	16	14
Surg to Anes	43	3.8	12 to CRN	12	1.1
CRN to Anes	40	3.5	SA to CRN	8	0.7
CRN to SA	33	2.9	Anes to Surg	8	0.7
Surg to NA/AA	33	2.9	NA/AA to Surg	5	0.4
CRN to Res	30	2.7	NA/AA to CRN	5	0.4
Surg to SN	29	2.6	Anes to CRN	4	0.4
CRN to Oth	28	2.5	SN to CRN	4	0.4
CRN to SN	23	2	RN to CRN	3	0.3
CRN to NA/AA	22	1.9	SN to Surg	1	0.1
Surg to NT	21	1.9	Anes to CRN	1	0.1
Surg to Oth	18	1.6	ChN to Surg	1	0.1
CRN to NT	16	1.4	ChN to CRN	1	0.1
Surg to MedSt	11	1	NR to CRN	1	0.1

Anes = anesthesiologist; ChN=charge nurse; CRN= circulating registered nurse; MedSt = medical student; NA/AA = certified registered nurse anesthetist or anesthesia assistant; NR=nurse relief; NT = nurse technician; Oth= other; Res= resident; SN = student nurse; Surg = surgeon; SA= surgical assistant

The network sociograms shown below are visual representations of the communication and relationship ties observed in each of the surgeries included in the analysis. Table 6, which provides the social network statistics metrics computed from each network graph follows, highlighting especially the roles of the surgeon and CRNs as critical nodes. ***Please refer to Appendix 3 for definitions of the important – and highly specific – SNA terms used in the remainder of this section.***

Figure 4

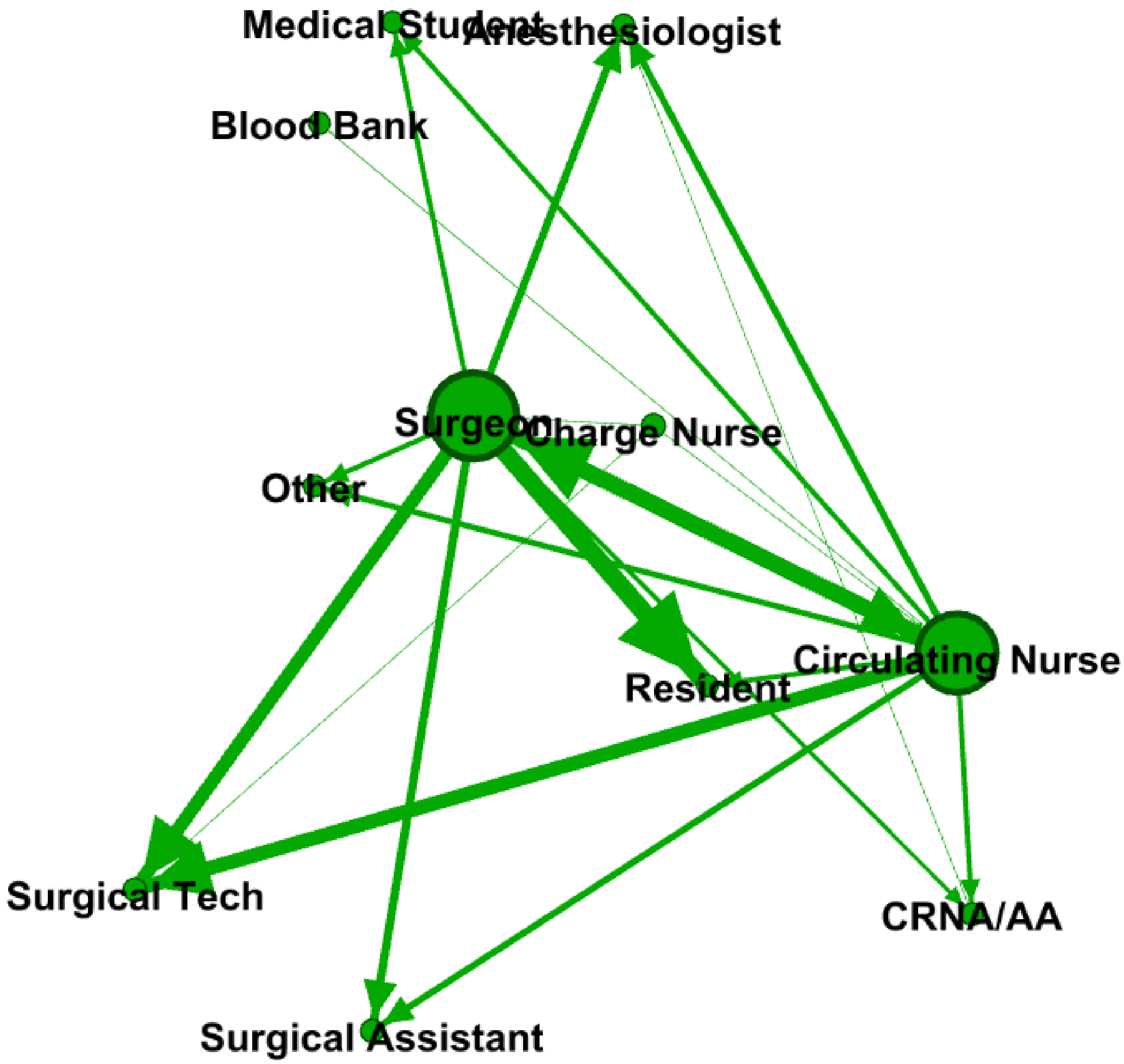
Surgical Case 1



Surgical case one was a laparoscopic cholecystectomy that lasted 59 minutes with 12 different roles and 127 communications (34 unique source-target pairs) observed. The lines are edges- the thicker the line the more directed communication. The graph is not considered particularly dense, that is, there is not a lot of connectedness between the actors/nodes. Of note, many roles received information from the surgeon and the circulating nurse.

Figure 5

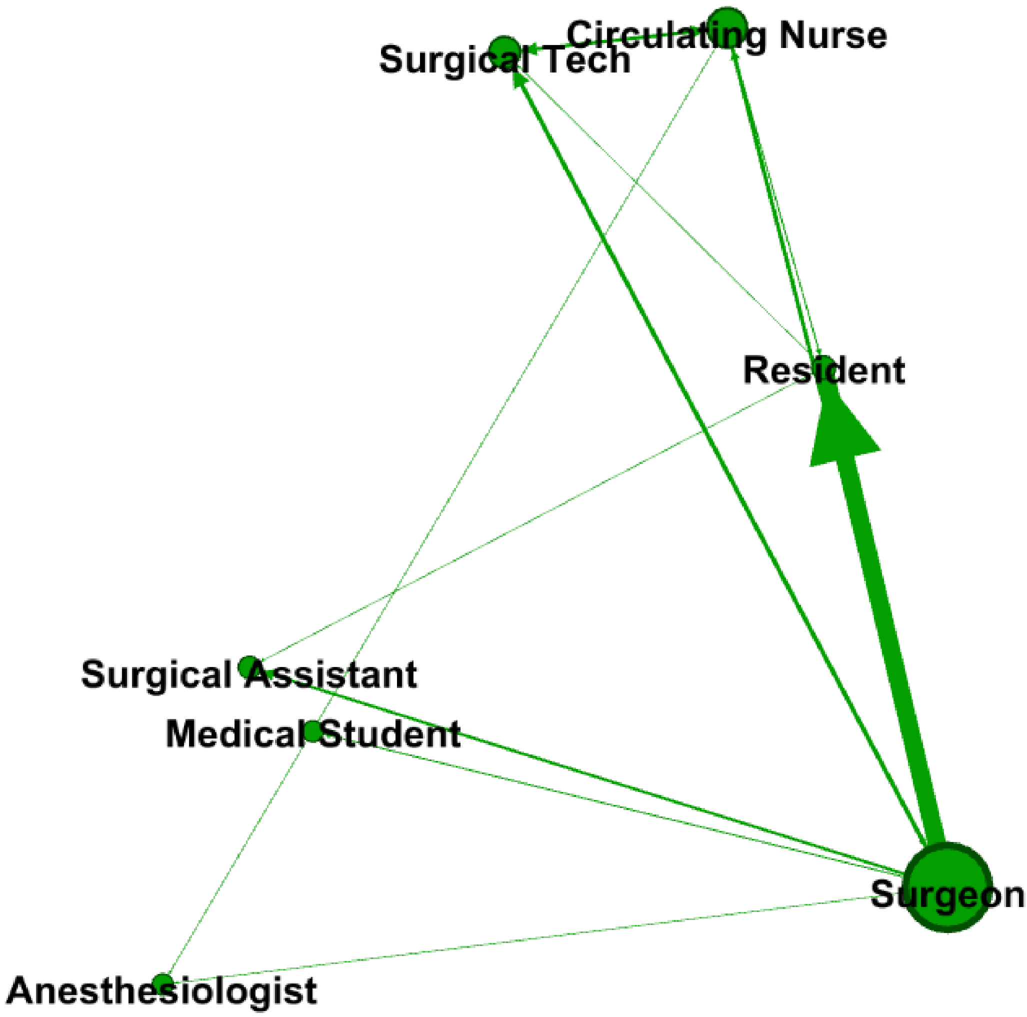
Surgical Case 2



Surgical case 2 was a lap chole that lasted 83 minutes with 11 different roles and 177 communications (24 unique source-target pairs) observed. There are a number of thickened edges indicating lots of directed communication among the surgeon, CRN, resident and tech. The graph is dense (a high clustering coefficient). Most communications are coming from the surgeon and the CRN.

Figure 6

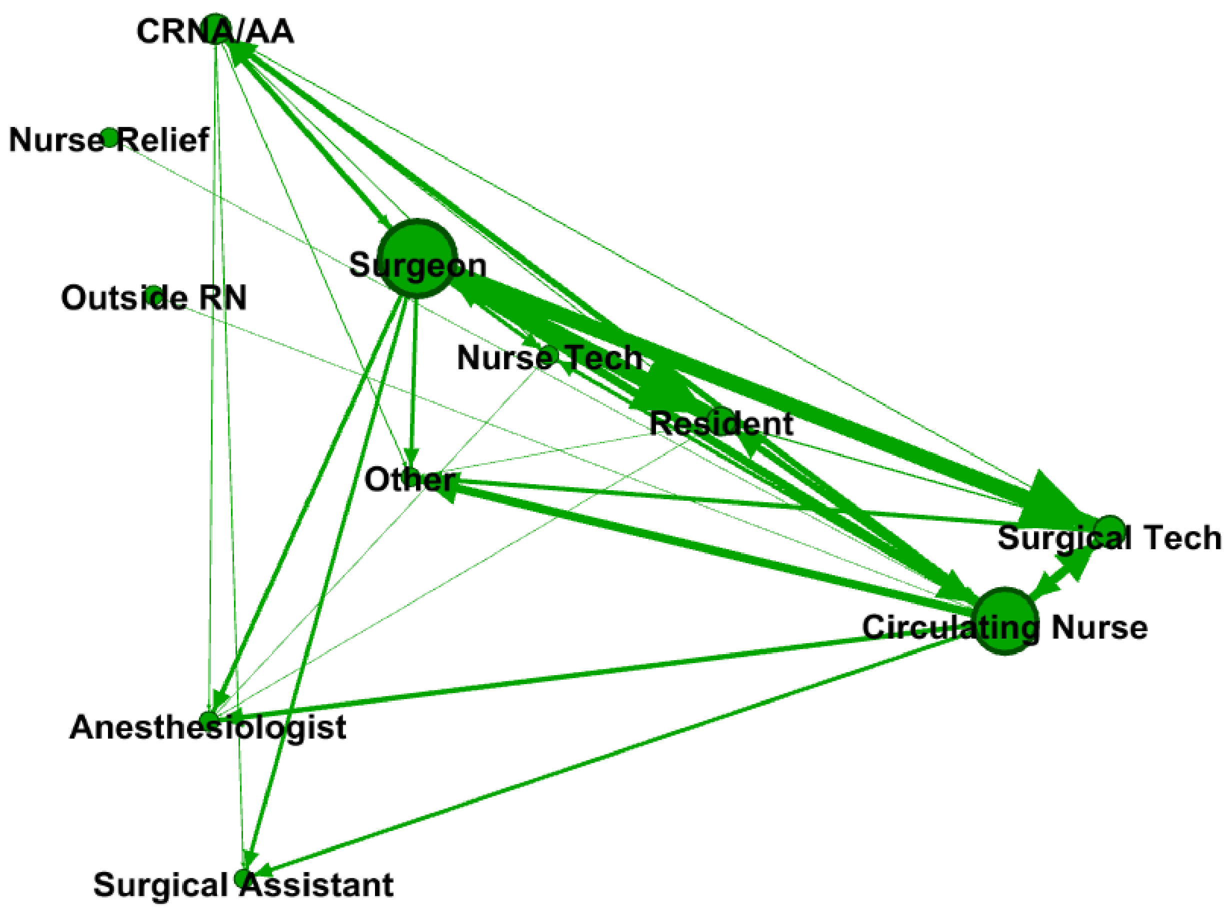
Surgical Case 3



Surgical case 3 was an appendectomy that lasted 61 minutes with seven different roles and 83 communications (15 unique source-target pairs) observed. There are only seven actors in this graph. It has low density. It is interesting to note the surgical technician and the nurse are at the same distance from the surgeon and the size of the node is similar. The surgeon communicates most with the resident as represented by the thick edges.

Figure 7

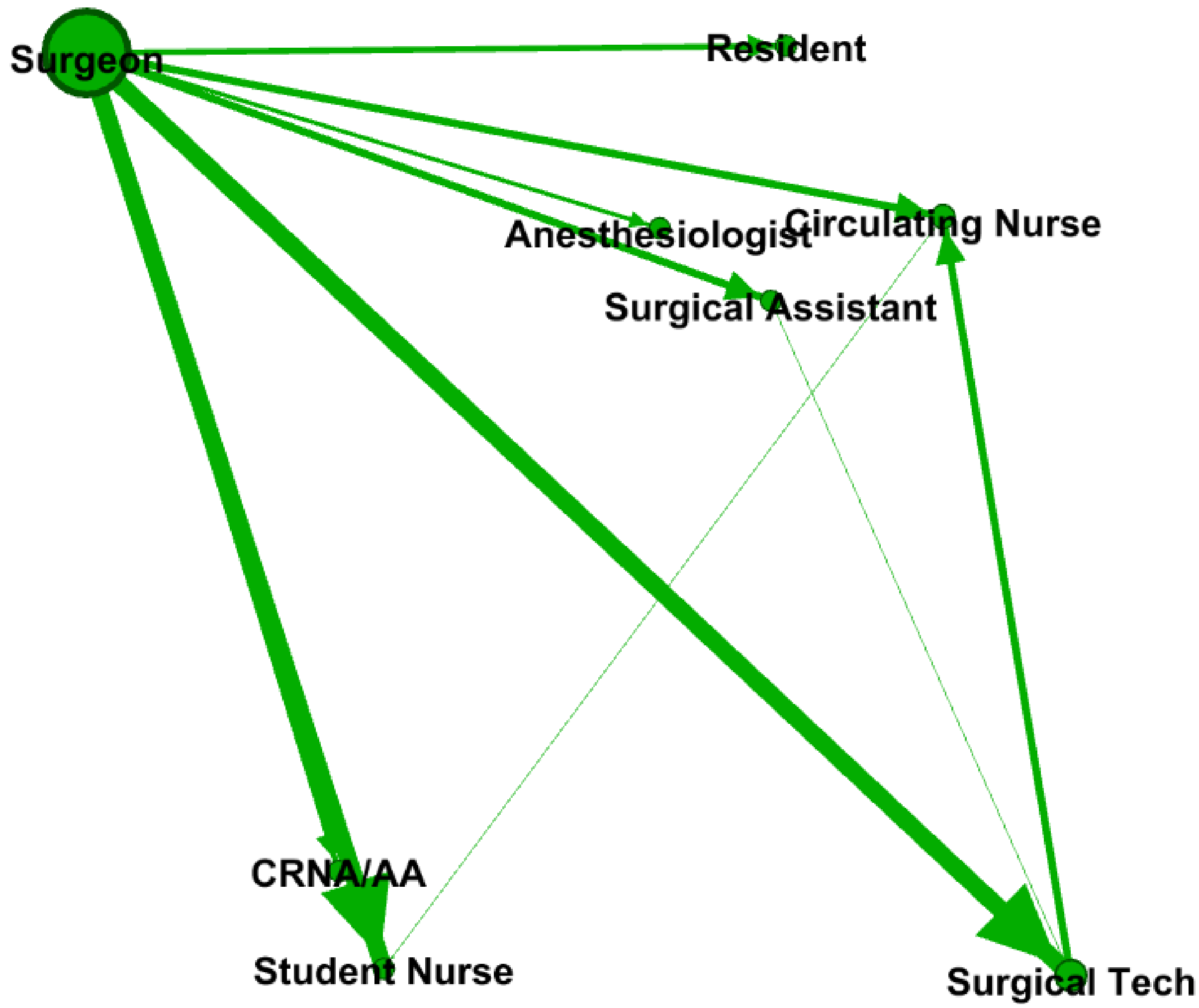
Surgical Case 4



Surgical case 4 was a Whipple procedure that lasted 156 minutes, the longest surgery observed. There were 11 different roles, with the most communications (271; 39 unique source-target pairs). The surgeon has the most directed communication to the resident, surgical technician, CRN and surgical assistant. What is unique in the graph is the position of the non-licensed nurse tech positioned between surgeon and resident. There was an issue with the table in the middle of the case that required the tech to come and assist.

Figure 8

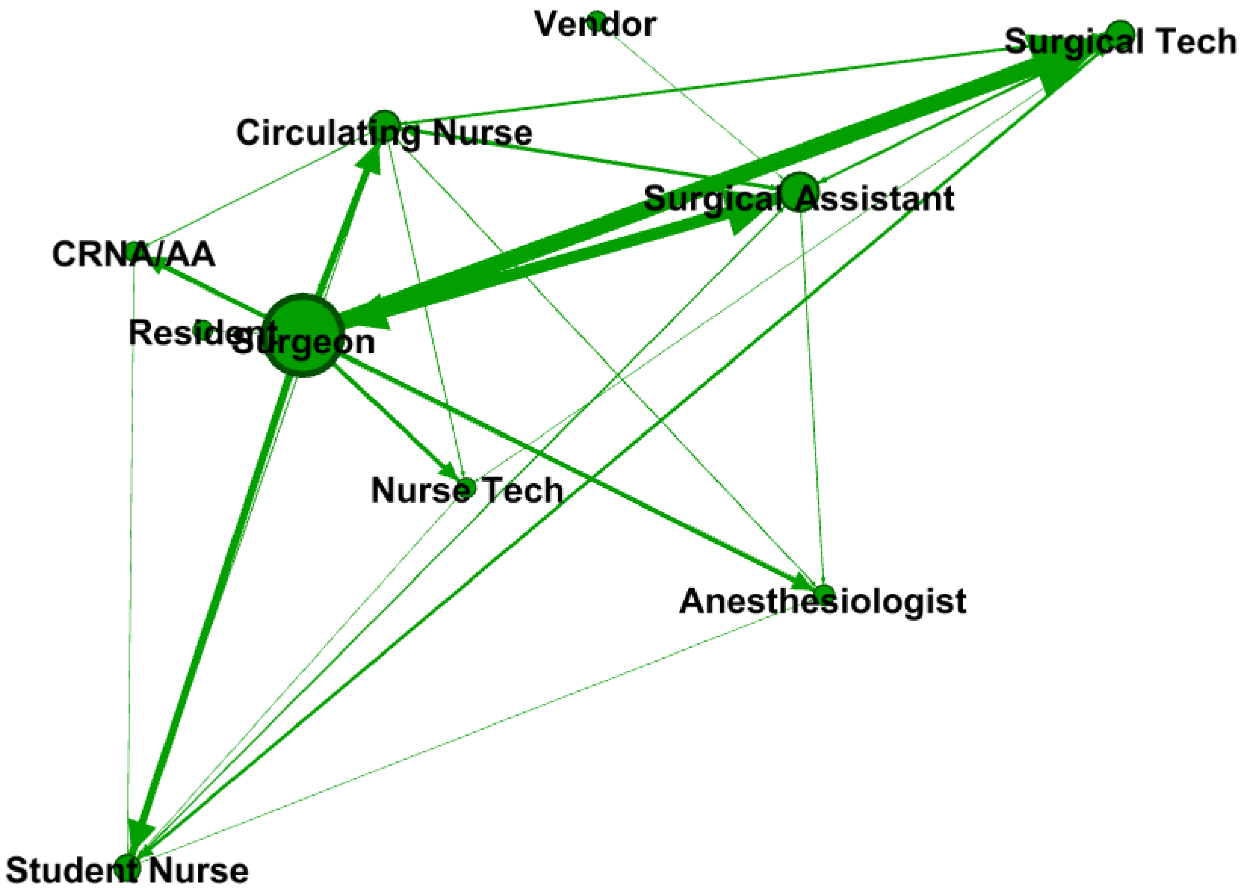
Surgical Case 5



Surgical case five was a laparoscopy that lasted 51 minutes with eight different roles and 52 communications (12 unique source-target pairs) observed. The graph has very low density. In comparison to surgical case observation two, there are fewer players, and the communication mostly emanates from the surgeon, making his role that of an authority. Most of the communications to the CRN are coming from other roles instead of the CRN facilitating those communications.

Figure 9

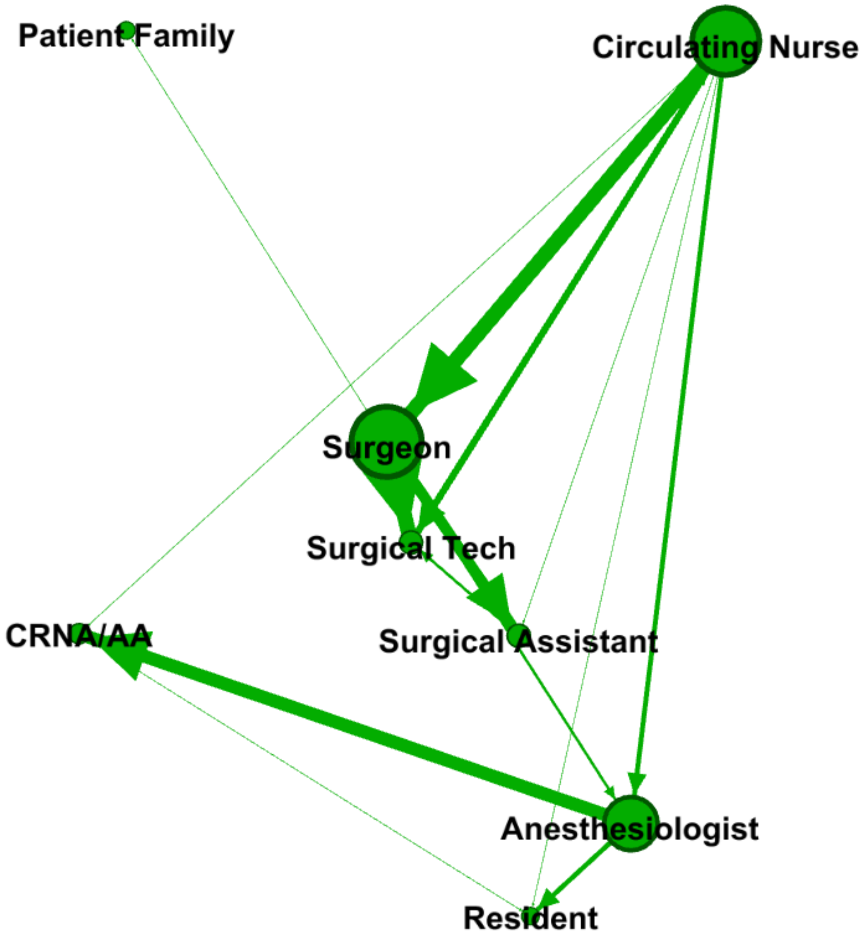
Surgical Case 6



Surgical case 6 was a lap chole that lasted 73 minutes with 10 different roles and 195 communications (35 unique source-target pairs) observed. This case has greater density than the previous five cases. The case length is higher than surgical case five. This is the first case where a vendor, a representative of a medical equipment or supply company with specialized expertise, was present, and he is communicating to the surgeon through the surgical assistant

Figure 10

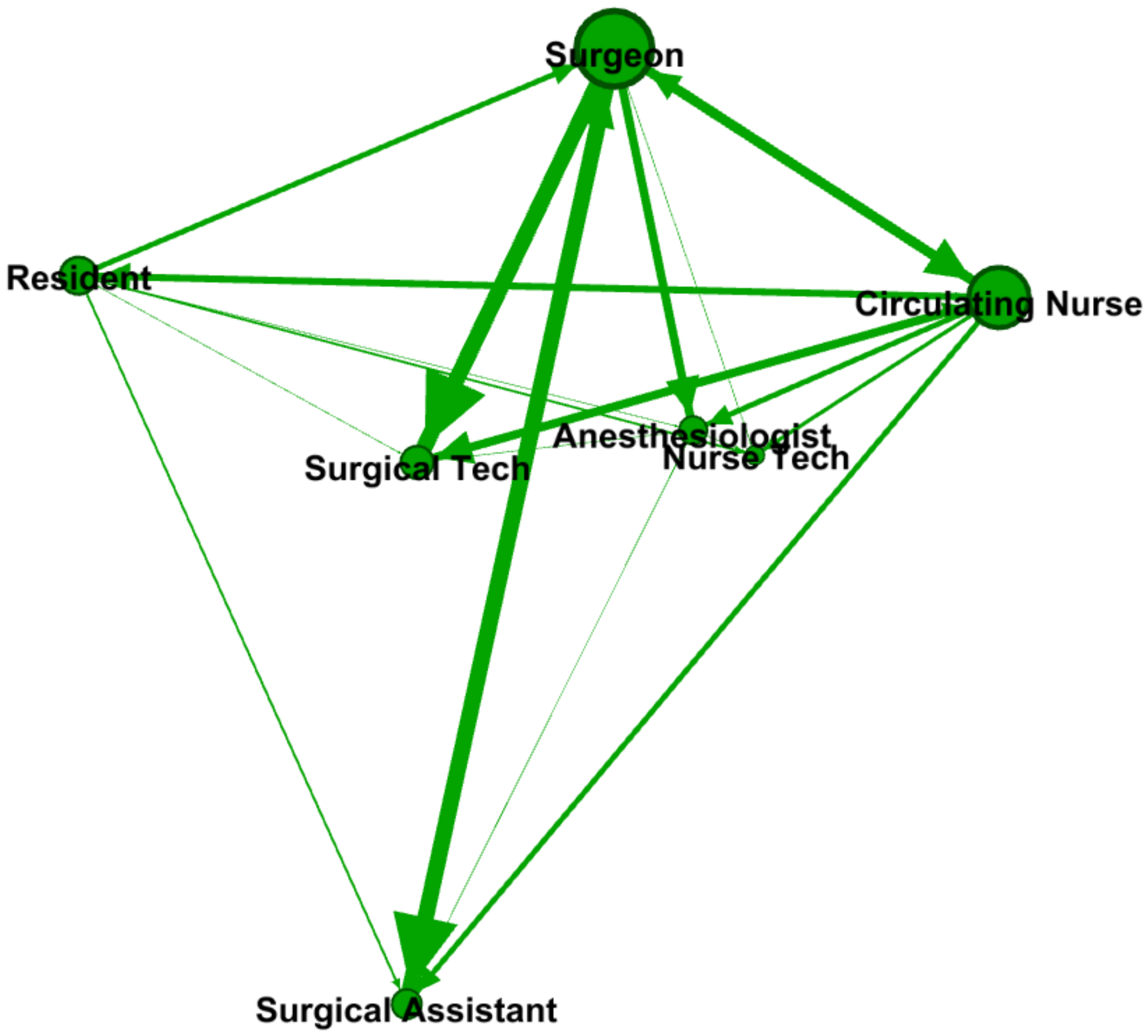
Surgical Case 8



Surgical case 8 was a lap chole that lasted 32 minutes with 8 different roles and 55 communications (18 unique source-target pairs) observed. Like in figures, one, two and four, the nodes for the surgeon and CRN are similar is size- they are the prominent actors. This is the first graph that shows wide edges coming from the CRN to the surgeon indicating the CRN was talking to the surgeon more that he was to the CRN. There is moderate density. This was the shortest case observed with eight roles participating. The circulating nurse has the most edges indicating the CRN is the hub.

Figure 11

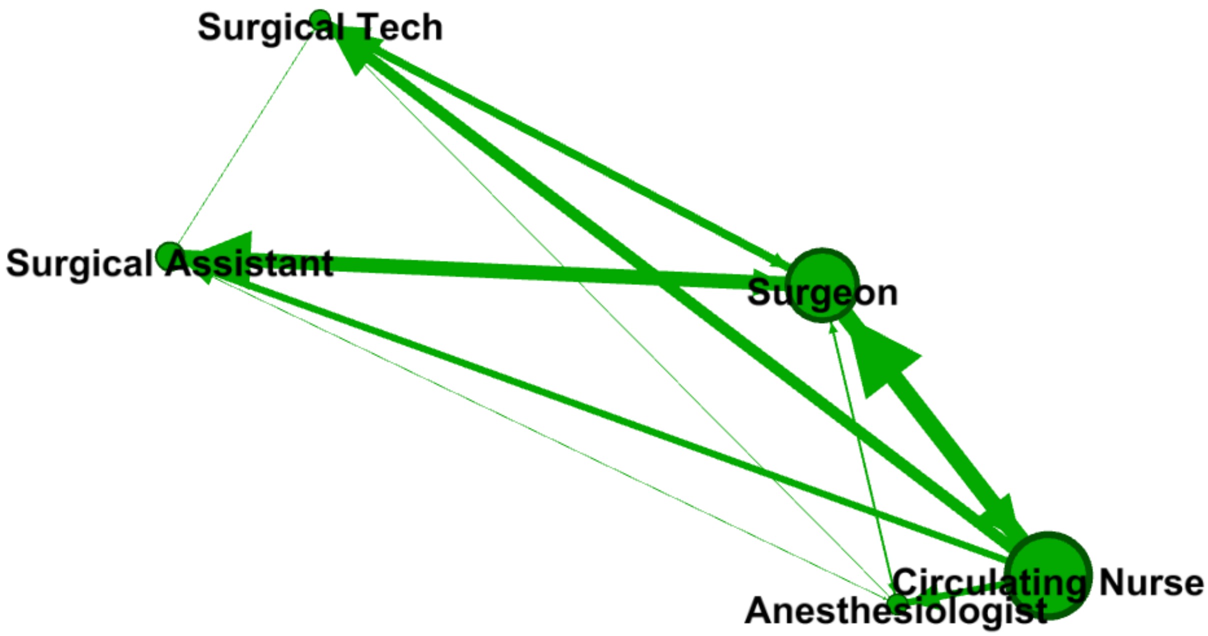
Surgical Case 9



Surgical case nine was a lap chole that lasted 101 minutes with seven different roles and 98 communications (30 unique source-target pairs) observed. This case has a high density with the nodes for the CRN and surgeon are similar in size. There are strong edges coming from the surgeon to the surgical assistant and surgical technician. The CRN is the hub, the role from which the most communication flows, but shares the authority (communication coming into CRN) with the surgeons.

Figure 12

Surgical Case 10



Surgical case 10 was a laparoscopy that lasted 102 minutes with five different roles and 73 communications (18 unique source-target pairs) observed. The surgeon and the CRN are again equal in node size. They are the prominent actors participating in this surgery. This model has very high density indicating a high degree of connectedness among the actors. This case was the second longest in the series but nowhere near as complex or long as figure four.. The CRN is the largest node with the most connections. The CRN and surgeon are both the hub and authority.

Associations with Case Length (Correlations)

SNA Network level graph metrics

In order to gain insight into each surgical graph network, three key SNA network-level metrics were used: graph density, defined as the number of edges divided by the total possible number of edges in a graph; average clustering coefficient, defined as the ratio of the number of edges between the neighbors of a role (node) to the maximum number of edges that could possibly exist between the neighbors of that role (node), averaged over all nodes for that graph; and modularity, which measures the strength of division of a network into modules or cliques. Each of these statistical metrics ranges from 0-1:

Graph Density: represents the ratio between the edges present in a graph and the maximum number of edges that the graph can contain. Conceptually, it provides an idea of how dense a graph is in terms of edge connectivity.

Average Clustering Coefficient: a graph that has nodes with fewer than two neighbors is assumed to have a clustering coefficient of 0 whereas graphs with nodes with more connected neighbors has a cluster coefficient closer to 1.

Modularity: values above zero means that the nodes inside the modules or “cliques” are more densely connected than would be expected by chance, where networks with high modularity having dense connections between the nodes within modules, but sparse connections between nodes in different modules.

Table 6 reports these three network level metrics for the nine surgeries. In this table, surgery #10 has the highest graph density (most dense) and average clustering coefficient whereas surgery # 5 had the lowest (sparsest) graph density and average clustering coefficient. Surgery #8 had the highest modularity and was the shortest surgery. Overall, all three metrics had large effect size. i.e., correlations (Spearmans' rho (ρ) absolute value > 0.5) with case length duration. Graph density and average clustering coefficient were both positively associated with case length with the strongest association between the average clustering coefficient and duration ($\rho=0.733$, $p=.025$, see Figure 13) which was also statistically significant indicating that longer surgeries yielded denser network graphs. Modularity for the graphs was negatively associated with case duration ($\rho=-0.594$, $p=.092$) indicating that surgeries with higher modularity (more dense subgroups or "cliques" which are sparsely connected to each other) were associated with the shorter duration surgeries. It is also worth noting that modularity was inversely associated with graph density ($\rho=-0.653$, $p=.057$) and the average clustering coefficient ($\rho=-0.762$, $p=.017$) for these nine surgeries indicating that overall graph density was associated with fewer tightly knit modules.

SNA Role specific metrics (for CRN and Surgeon)

With respect to the CRN and surgeon roles, node or role level specific metrics were used from the SNA analyses to evaluate three centrality measures: closeness (which measures how efficiently the entire graph can be traversed from a given node – nodes with high closeness centrality will likely reach the entire network more efficiently); betweenness (indicates how important a given node is for connecting other pairs of nodes in the graph – nodes with higher betweenness centrality are considered key to ensuring the overall connectivity of the network); and eigenvector (also called relative centrality or prestige, is a measure of how connected that node is to other influential nodes in the graph). Since the communications observations also included the direction of the communications from the source role (or node) to the target role, two additional eigenvector centrality metrics were also computed for authority (incoming eigenvector centrality of a node that receives communications from many of the other nodes in the network) and hub (outgoing eigenvector centrality of a node that communicates to many of the other nodes in the network) reflecting the importance of that role relative to communications directed to them or from them. All of these metrics yield values from 0 to 1 with values closer to 1 indicating that node's relative importance to the graph (for their closeness, betweenness or eigenvector centrality).

As can be seen in Table 6, nearly all closeness and eigenvector centrality metrics for both the CRN and surgeon are close to 1 indicating that both the CRN and surgeon have high interconnected roles for reaching the rest of the roles in the network. It is also noted that in general the hub centrality metrics were higher than the authority metrics over all surgeries and for both the CRN and surgeon roles indicating that the importance of the CRN and surgeon are higher for their outgoing communications rather than for their incoming communications. When evaluating the association of these role specific metrics with case length duration, the centrality closeness metrics for both the surgeon ($\rho=0.505$, $p=.166$) and CRN ($\rho=0.712$, $p=.031$) yielded large correlation effect sizes with higher closeness metrics being associated with longer surgeries (Figs 13 and 14). Conversely, the higher the hub metric for the surgeon's role, the shorter the surgery ($\rho=-0.667$, $p=.050$, see Figure 15) which was statistically significant with a large effect size indicating that the more outgoing communications central to the surgeon role, the shorter the surgery was.

Table 5

SNA network graph metrics and role specific metrics and their correlations with case length duration (n=9)

Surgery	Duration (min)	Network Graph Metrics: Graph Density	Clustering Coefficient	Modularity	Role	Role Specific Metrics: Closeness centrality	Betweenness centrality	Eigenvector centrality	Authority (incoming)	Hub (outgoing)
1	59	0.258	0.580	0.051	CRN	1.000	0.420	0.866	0.314	0.664
					Surgeon	0.769	0.145	1.000	0.374	0.529
2	83	0.218	0.662	0.099	CRN	1.000	0.100	0.415	0.214	0.711
					Surgeon	0.900	0.378	1.000	0.280	0.652
3	61	0.357	0.493	0.124	CRN	0.800	0.044	0.796	0.314	0.548
					Surgeon	1.000	0.372	0.991	0.275	0.756
4	156	0.355	0.564	0.103	CRN	1.000	0.194	0.809	0.337	0.491
					Surgeon	1.000	0.017	0.808	0.313	0.495
5	51	0.214	0.304	0.149	CRN	0.467	0.012	1.000	0.426	0.282
					Surgeon	1.000	0.155	0.618	0.116	0.899
6	73	0.389	0.529	0.000	CRN	0.889	0.022	0.839	0.334	0.490
					Surgeon	1.000	0.175	1.000	0.358	0.505
8	32	0.321	0.477	0.276	CRN	0.875	0.310	1.000	0.328	0.705
					Surgeon	0.667	0.119	0.707	0.356	0.514
9	101	0.714	0.800	0.049	CRN	1.000	0.017	0.843	0.353	0.473
					Surgeon	0.778	0.083	1.000	0.388	0.466
10	102	0.900	0.900	0.000	CRN	1.000	0.083	1.000	0.461	0.474
					Surgeon	1.000	0.083	1.000	0.461	0.474
Correlation										
	rho (ρ)	**0.567**	**0.733**	**-0.594**	CRN	**0.712**	-0.067	-0.390	0.300	-0.217
	p-value	*.112*	*.025*	*.092*		*.031*	*.865*	*.300*	*.433*	*.576*
	rho (ρ)				Surgeon	**0.505**	-0.444	0.456	0.383	**-0.667**
	p-value					*.166*	*.232*	*.217*	*.308*	*.050*

Note: Correlations that achieved statistical significance (p<.05) are highlighted in yellow and correlations (rho) > 0.5 are emphasized in **bold** to note correlations with large effect sizes.

Figure 13

Plot of Surgical Case Length Duration by SNA Graph Metric: Average Clustering Coefficient

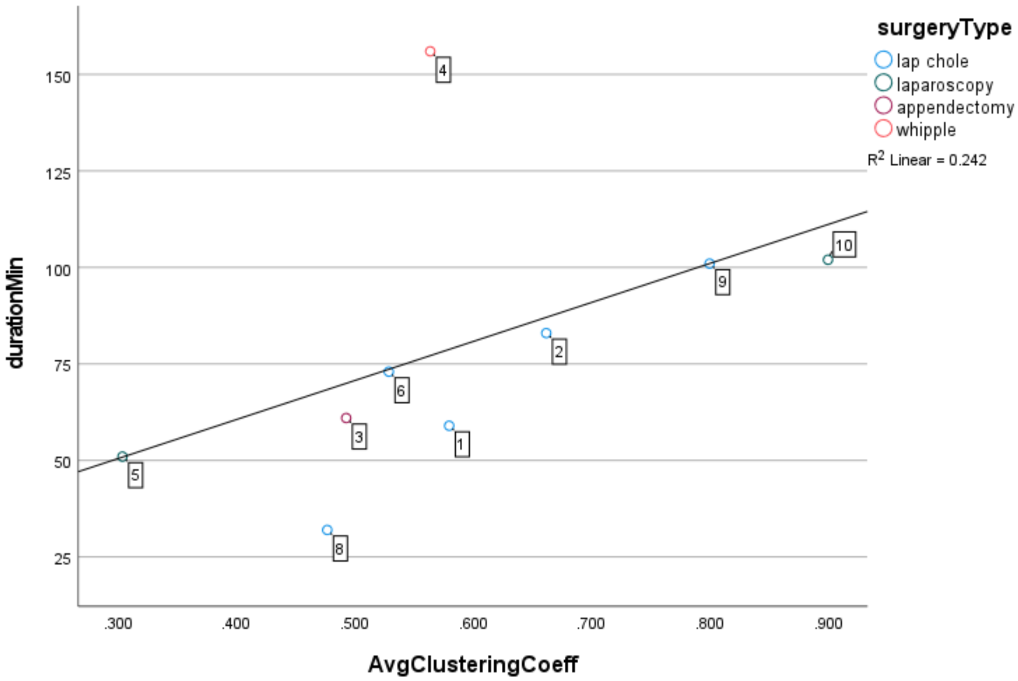


Figure 14

Plot of Surgical Case Length Duration by SNA Role Metric for CRN's Closeness Centrality

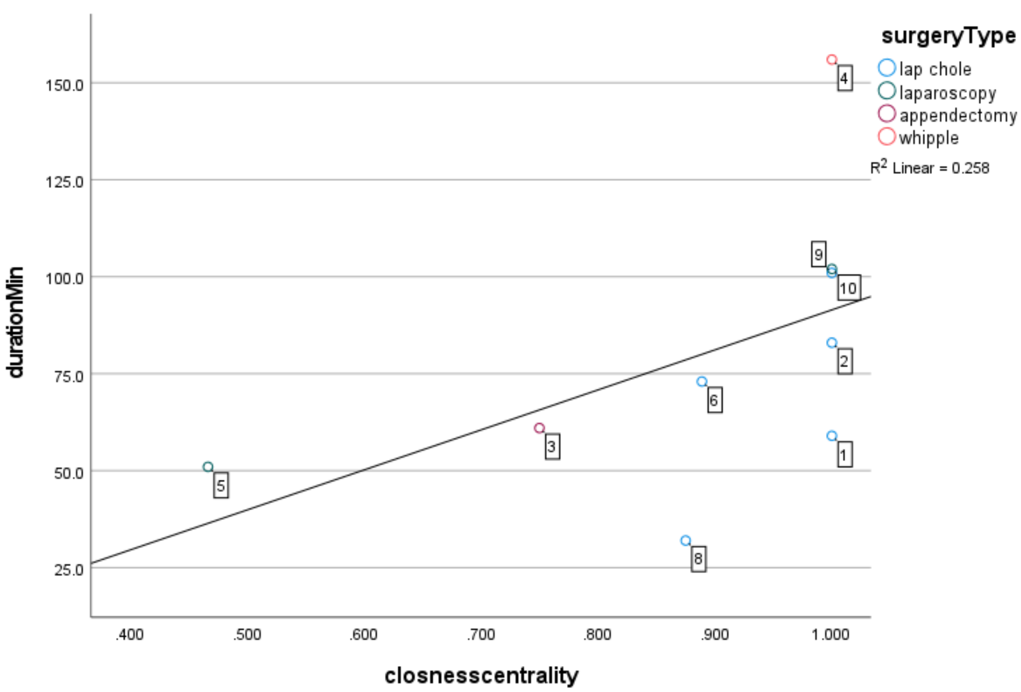
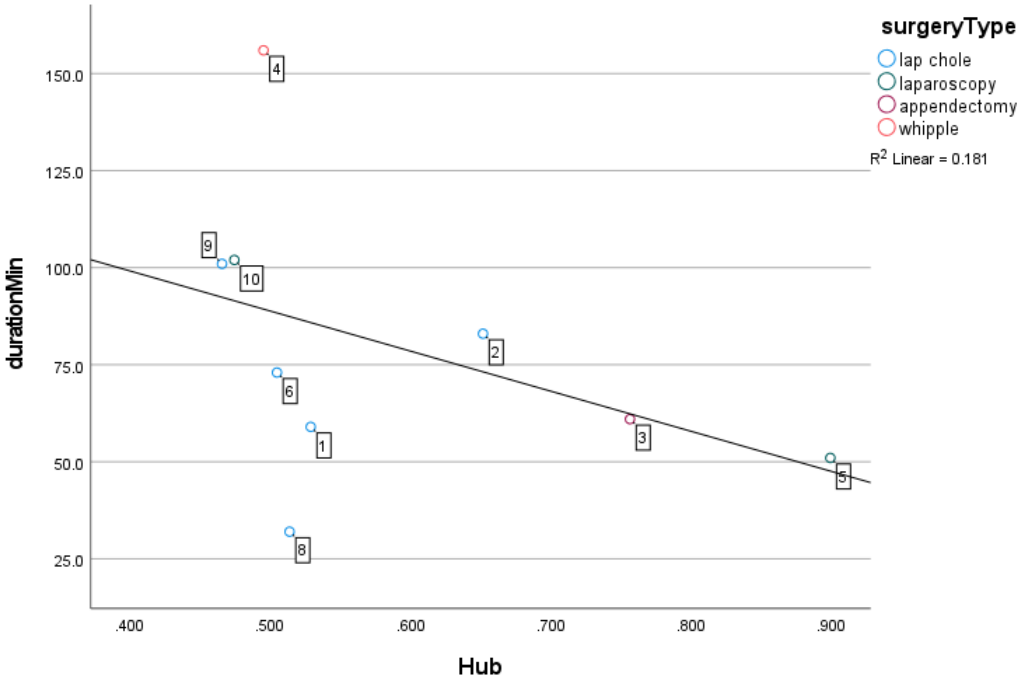


Figure 15

Plot of Surgical Case Length Duration by SNA Role Metric for Surgeon's Hub Eigenvector Centrality



Chapter 6

Discussion

Discussion

Findings

This study explored aspects of professional communications and relationships in the operating room using tools developed in the study of relational coordination and social network analysis. Results from this study provide a glimpse into patterns of interprofessional communications in the operating room, especially as relates to the role of the circulating registered nurse (CRN) and a look at some associations between patterns of communication and surgical case length.

Patterns of Communication and Relationships in the Operating Room

Results of the Relational Coordination (RC) survey would suggest poor interprofessional communications and relationships among the operating room crew members, specifically regarding case length duration. Respondents were clearly dissatisfied with the frequency of communication, level of shared knowledge, and respect for their contributions to managing the case, and half were unhappy with the accuracy of communications and what they perceived to be a focus on blame rather than fixing any problems.

In contrast to the survey results, however, direct observation of nine scheduled surgeries demonstrated highly functional interprofessional communications and working relationships. This discrepancy may be explained by the fact that over 90 percent of the survey respondents were anesthesia providers (anesthesiologists, anesthesia assistants, and certified registered nurse anesthetists, i.e., CRNAs). These essential members of the OR crew sat behind an opaque drape, outside of the surgical field (they did not don surgical attire), were completely separated from the work of the surgeon, and somewhat hidden from the CRN. This finding is consistent with other research related to OR communications and crew functioning (Fambrini & Gruber, 1999; Jones et al., 2021), reinforcing the need for creative solutions to what appears to be a potential threat to smooth communications and relationships in the operating room.

Results from the SNA provide some additional interesting observations about the CRNA and anesthesiologists. In only one of the cases (case 8) is the node size for the anesthesiologist close to the size of surgeon or CRN, and the anesthesiologist's communication in this case was primarily *with the CRNA*; other communications patterns in this case, e.g., between either of the anesthesia providers and the CRN or surgeon/surgical assistant were more consistent with other observed surgeries. Another of the sociograms (case 4), was the longest and most complex case observed. This is the only case where these was any observed communication emanating from the anesthesia provider to anyone else in the crew. In all the other cases, anesthesia providers were only communicating with each other. This finding raises even more questions about the relationship between these communication patterns and the presence of an opaque drape that physically separates the anesthesia provider from the remainder of the OR crew (Fambrini & Gruber, 1999; Jones et al., 2021). Taken together with the findings from the RC survey, there is opportunity for future research to understand these patterns more completely, and to see how modifying the work environment for anesthesia providers might change professional communications and relationships in the OR.

Members of the OR crew

Operating room staff function more like crews than teams, that is, although the *roles* of the crew members stay the same, e.g. surgeon, circulating nurse, anesthesia provider, the individuals performing the *tasks* associated with those roles often vary. Each of these roles has its own set of responsibilities but they all have one thing in common- the patient on the operating room table. Five of these roles, i.e., surgeon, surgical assistant, surgical technician, anesthesia provider, and circulating registered nurse, were present in all nine observed surgeries, making up what might be called the *essential* operating room staff, and future research into operating room communications would do well to focus on these five roles.

Overall communications and surgical case length duration

The overall aim of this study was to describe the relationships and communications among members of operating room crews as they related to the time patients spend in the operating room. In SNA there is a term called centrality. Centrality measures the importance of the node (role) to the overall structure of the network. There are different types of centrality (degree, closeness, betweenness, eigenvector) that are defined in Appendix 3. Centrality is measured from zero to one- one indicating a high degree of centrality. Referring to Table 6, both the CRN and surgeon have a high degree of both closeness and eigenvector centrality. This means that they are the most important people in the network because people can easily reach them and they both are highly influential within the network.

The relationship between surgical case length duration and overall communications in the operating room – as represented by the average clustering coefficient – was clearly demonstrated, i.e. longer surgeries were associated with more communications. Figure 13 is a graph that explores clustering coefficient. This “clustering” together is what SNA refers to as cliques. Cliques are groups of people who are tightly connected to each other. The clustering coefficients in this study indicated that increased numbers of cliques are associated with an increase in time in the operating room. By contrast, in cases in which a singular individual (in this case surgeon or CRN) managed the flow of communication, less time was spent in the operating room. This is most evident in cases five and eight where the surgeon and the nurse were the facilitators of communication (hub). Neither of these have evidence of cliques and both have low density.

The data from the sociograms is compelling; the surgeon is the authority for most of the surgeries. In SNA, *authority* does not necessarily define a power position, rather, it is a position that receives large amounts of information through the communications going on in a particular space, meaning he/she is linking together nodes that are connected to other nodes. In the operating room, the authority is often the individual or actor that determines what information is shared {Borgatti, 2009}. Interestingly, both surgeon and CRN seem to trade off being the center of spoke and a wheel or hub. They both have high centrality, meaning that information must travel through them to get to other actors. The total number of ties or connections characterize the centrality actors have. It may also be defined by the probability that an actor lies between two other actors. Finally, how close actual actors are to each other can define centrality. Both surgeon and CRN are important in directing communication in the operating room in nine out of the nine surgeries included in the analysis. The results of this study align well with Donebedian’s model, showing a possible association between the OR crew members (structure), patterns of communication and relationships among those crew members (process) , and time spent in the operating room (outcome).

Role of the Circulating Registered Nurse

The feedback from the RC survey only included one CRN. Future studies will need to focus on better ways to recruit CRNs into studies of this kind. During early meetings with the OR staff, they expressed concern about the confidentiality of responses and possible backlash by hospital leadership. Although this was addressed directly in face-to-face meetings and on the informed consent, this fear may help explain why only one RN participated. Although low response rates are common in studies like this(Corner & Lemonde, 2019; VanGeest & Johnson, 2011), the almost complete lack of registered nurse participation raises important questions and challenges for future studies

The direct observations provided insight into the role of the CRN. As the sociograms illustrated, the circulating registered nurse was a primary node (actor) in eight of the nine cases. The CRN role was often similar in size to the surgeon- they both shared similar responsibility for what was going on in the operating room. Whether an increase in communications through the CRN contributes to the increased surgical case length duration, or the longer cases require more communication through the CRN remains to be determined, but these results open opportunities to explore the relationships between the amount of communication and the other tasks involved in the CRN role in a modern operating room.

Interpretation

The results of this study provide an interesting contrast to the results reported by the recent study by Tørring, et al. (2019). Those authors used a relational coordination framework to analyze the results of 15 structured interviews from members of 39 different surgical teams. Their findings highlighted the role of mutual respect and its importance to improving relational coordination in surgical teams. By contrast, this study found that the CRNA respondents to the RC survey indicated they felt a distinct lack of mutual respect that affected the perceived communication in the operating room. This was corroborated by the observations showing very little interprofessional communications between anesthesia providers and either the surgeon or CRN. There may be many reasons for these disparate results, and this is another area for future research.

The use of SNA and relational coordination (RC) together provide a clearer picture of communications in the operating room than previous studies using single methods. This can be seen most clearly in in Figure 3 and all the sociograms. Through the survey results, the CRNAs and anesthesiologists indicated that communication was not frequent enough. More than. 85% of their responses were undesirable, meaning frequency of communication was either absent or rare. This coincides with both the position and the amount of communication depicted in all the sociograms. The node representing anesthesiologists and CRNAs is always outside of the clustering of the surgeon, surgical assistant, and surgical technician. Furthermore, apart from cases 2 and case 8, there is no directed communication coming from the anesthesiologist or CRNA- it is all directed toward them. In a 2009 study of silence and power in the operating room, it was suggested that silence by members of the OR crew suggests a play for power (Gardezi et al., 2009). Effective communication is a way to enhance team performance and facilitate better outcomes for the patient (Brock et al., 2013; Hargestam et al., 2013; Varpio et al., 2008). A future study using SNA and RC to assess communication patterns and positional power would be interesting and beneficial.

There has been renewed interest in patterns of communication and relationships in the OR and the relationships between those patterns and various surgical outcomes (Daley et al., 2015; Havens et al., 2010; Rodziewicz et al., 2021; Tørring et al., 2019). Some of these employ a RC framework (Gittell et al., 2000; Havens et al., 2010; Tørring et al., 2019) and some use SNA (Anderson & Talsma, 2011; Hertzberg et al., 2017; Parnell & Robinson, 2018; Pasarakonda et al., 2021) but none combined both, and none looked at surgical case length as an outcome. By using both methods together, this study provided some preliminary insights into how patterns of communication related to surgical case length, and the central role of the CRN in those communication patterns. As was seen in Figure 14, as frequency and volume of communication with the CRN increased, so did surgical time. Investigators interested in exploring factors related to surgical case length duration should consider employing multiple methodologies to get the fullest possible picture of OR operations.

Probably most important to this study is that the surgeon and the CRN are the most prominent nodes in the nine sociograms included in the analysis. A closer look into the data identified that the circulating nurse had the most connections to actors inside and outside of the surgery. Other actors were required to pass information through the CRN in fifty percent of the cases and they are the hub, which means they have the largest amount of information coming from them. The location within the sociograms of the surgeons were very similar. Ninety percent of the observations show that surgeon had the most ties. Other actors had to pass information through the surgeon in seventy-five percent of the surgical cases and the surgeon was the hub (person sending out most communication) in seventy percent of the surgical cases.

Limitations

This study was conducted in a 300-bed Catholic affiliated teaching hospital that is part of a large multi-hospital system in an urban area and may or may not be generalizable beyond that setting. In addition to the limitations inherent in the setting, the response rate to the RC survey was small (28%) and of those who did respond, the vast majority (29 out of 34 respondents) were certified registered nurse anesthetists. Other professionals may have vastly different perceptions of the quantity, quality, and content of communications in the OR, and different perspectives on the nature of the relationships around shared knowledge, shared goals, and mutual respect. Had circumstances allowed, it might have been useful to follow up with selected staff to learn why they chose not to participate, but it was not possible for this study. In addition, the survey was only offered electronically. Had there been paper forms distributed in breakrooms or staff meetings there might have been better response. The small sample size (n=34) also meant there were limitations to the types of analyses that could be performed with the data from the RC survey.

Although the direct observation yielded over 1100 total data points for the social network analysis, only ten surgeries were observed and only nine were analyzed. More observations might have changed the dynamics of the network diagrams. Limiting the observations to only general surgery cases was also a limitation, although it may have been appropriate since these are the most frequently performed surgeries.

Implications for nursing practice and research

This study is important because it demonstrated the feasibility of applying two unique research methodologies to the operating room setting. The concept of a “crew’ in healthcare is not well studied or recognized and using the combined methods in this study suggests it may be feasible for use in other places in healthcare with similar work crew dynamics, such as the emergency department.

This study also explicated and helped define the role of the circulating registered nurse within the social network of the operating room. The importance of this role should be considered in efforts to improve OR crew communications and relations, as well as in interventions seeking to reduce errors in the OR. Finally, this study showed that metrics derived from SNA can be used to describe the relationship between communication patterns in the operating room and surgical case length duration. Future research with larger sample sizes may provide even clearer evidence of these relationships.

Final thoughts

This study explored patterns of communications and interprofessional relationships in the operating room using tools from work in Relational Coordination and Social Network Analysis. Both modalities offer researchers important tools to explore critical, non-technical skills such as interprofessional communications, that have a direct effect on surgical case length duration and, hence, patient outcomes (Daley et al., 2015; Procter et al., 2010). There were some important outcomes of this study; a) there is an association between the frequency and volume of communication and case length duration. b) when there is a single leader (hub) facilitating most of the communication, there is less time spent in the operating room; and c) increased volume of communication and more complex, and dense crews (graph density) are associated with more time spent in the operating room.

As noted, longer operating room times have been associated with increased surgical complications, so it will be critically important to continue exploring modifiable factors associated with surgical case length duration, and to design and test interventions to mitigate their effects.

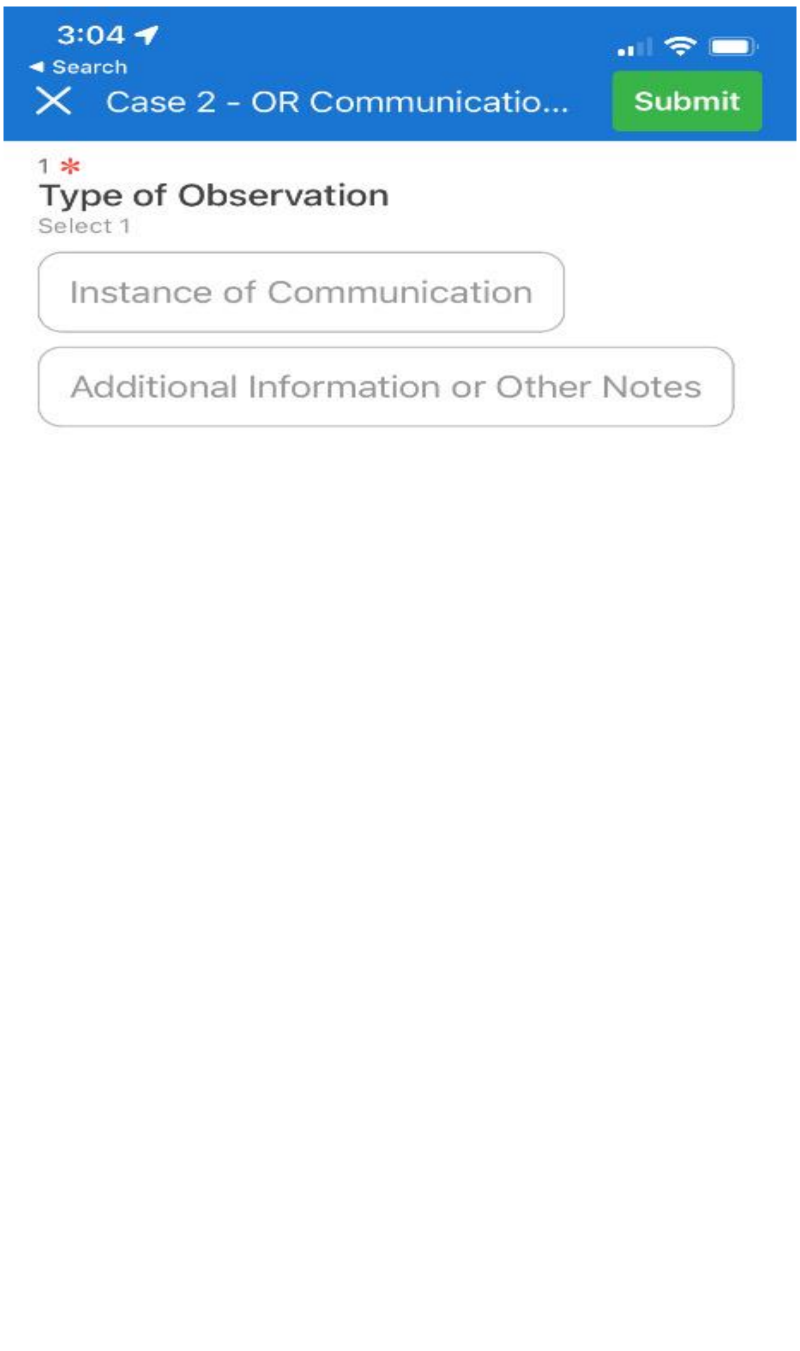
Appendices

Appendix 1- Relational Coordination Survey

Item	1	2	3	4	5
1. Frequent Communication How frequently do people in general surgery teams communicate with you about case length duration?	Not Nearly Enough	Not Enough	Just the Right Amount	Too Often	Much Too Often
2. Timely Communication Do members of the surgical team communicate with you in a timely way about how long the case will take?	Never	Rarely	Occasionally	Often	Always
3. Accurate Communication Do members of the surgical team communicate with you accurately about how long the case will take?	Never	Rarely	Occasionally	Often	Always
4. Problem Solving When there is a problem with how long the case is running, do members of the surgical team blame others or work with you to solve the problem?	Always Blame	Mostly Blame	Neither Blame Nor Solve	Mostly Solve	Always Solve
5. Shared Goals Do members of the general surgery teams share your goals for keeping the case running on time?	Not at All	A Little	Somewhat	A Lot	Completely
6. Shared Knowledge Do members of the surgical team know about the work you do to keep cases running on time?	Nothing	A Little	Some	A Lot	Everything
7. Mutual Respect Do members of the surgical team respect the work you do to keep cases running on time?	Not at All	A Little	Somewhat	A Lot	Completely

Appendix 2

Screens in QuickTapApplication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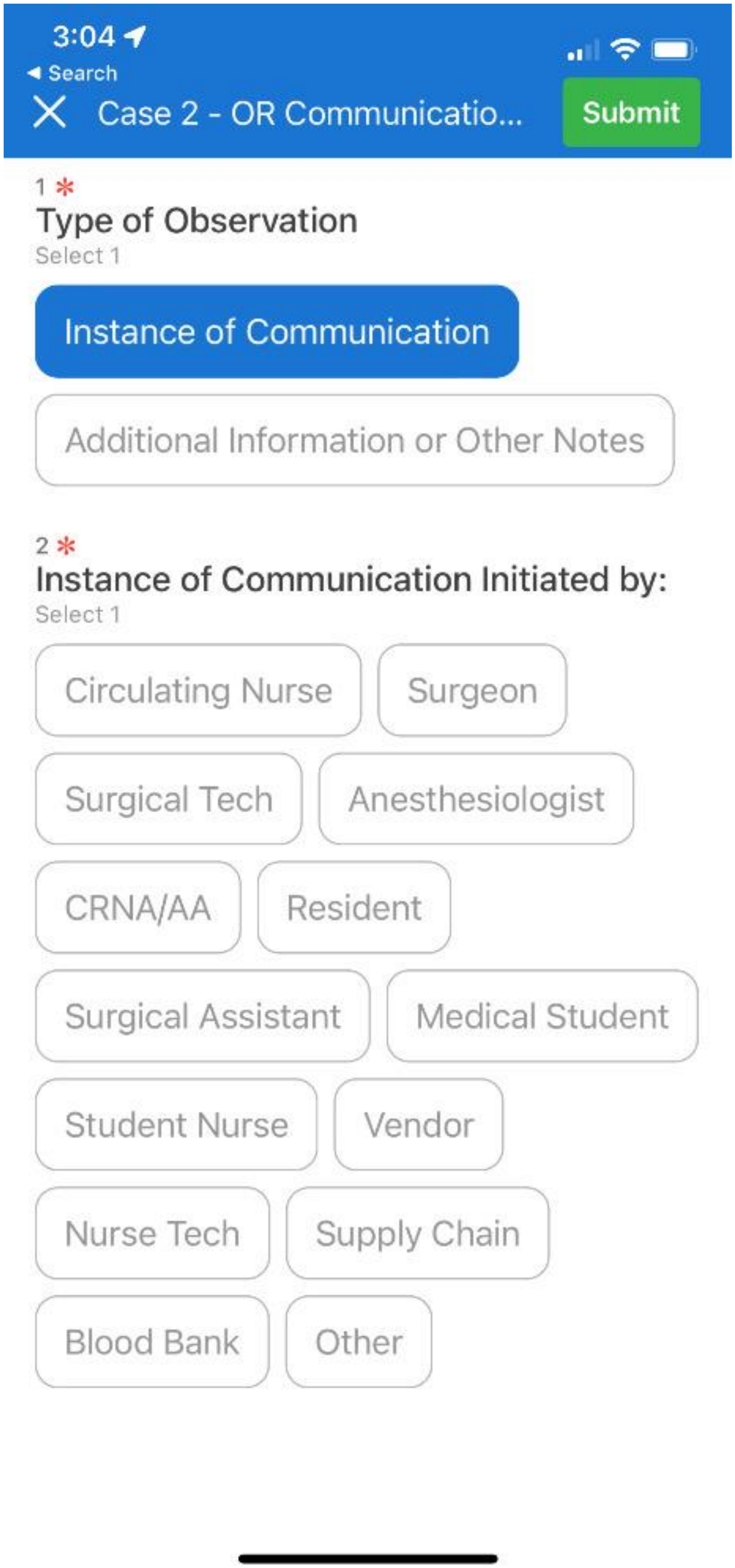
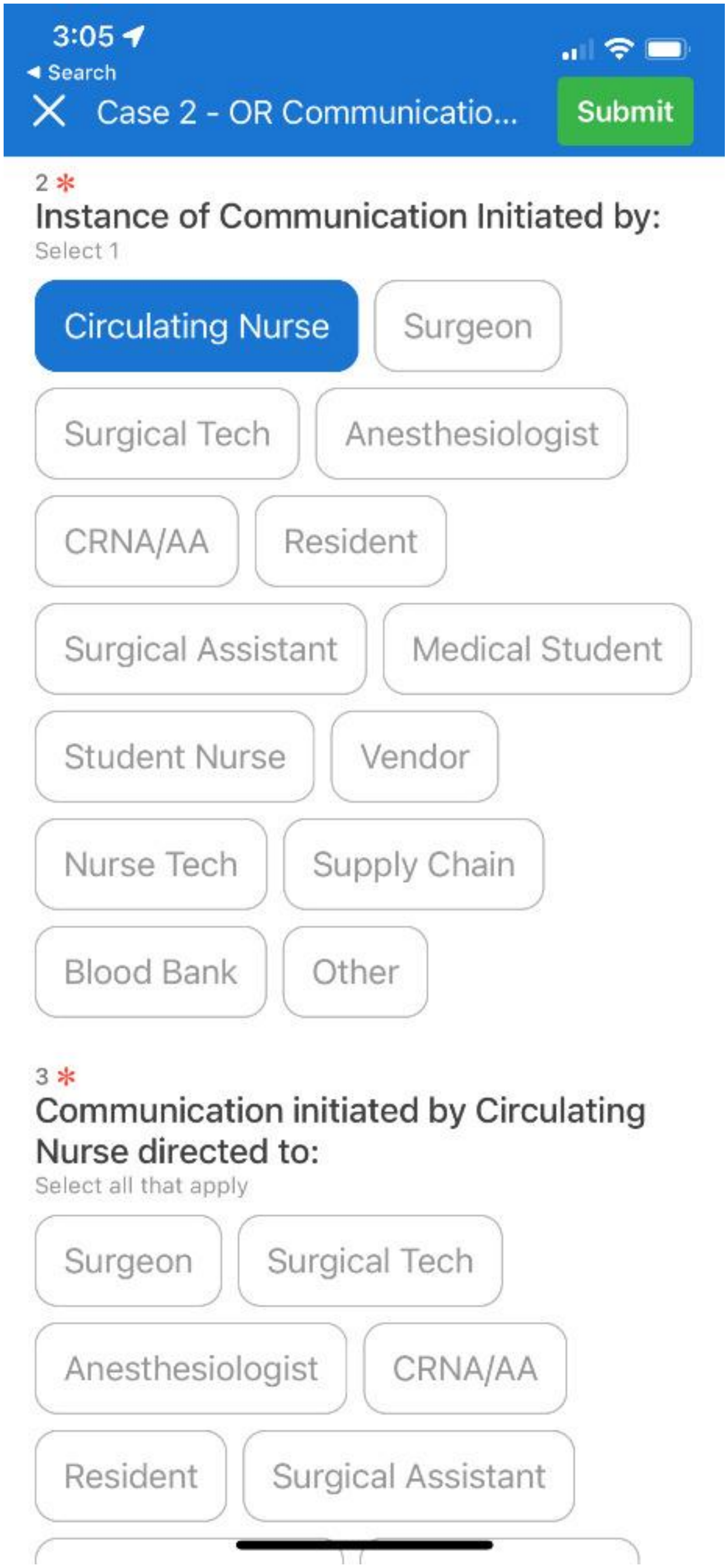
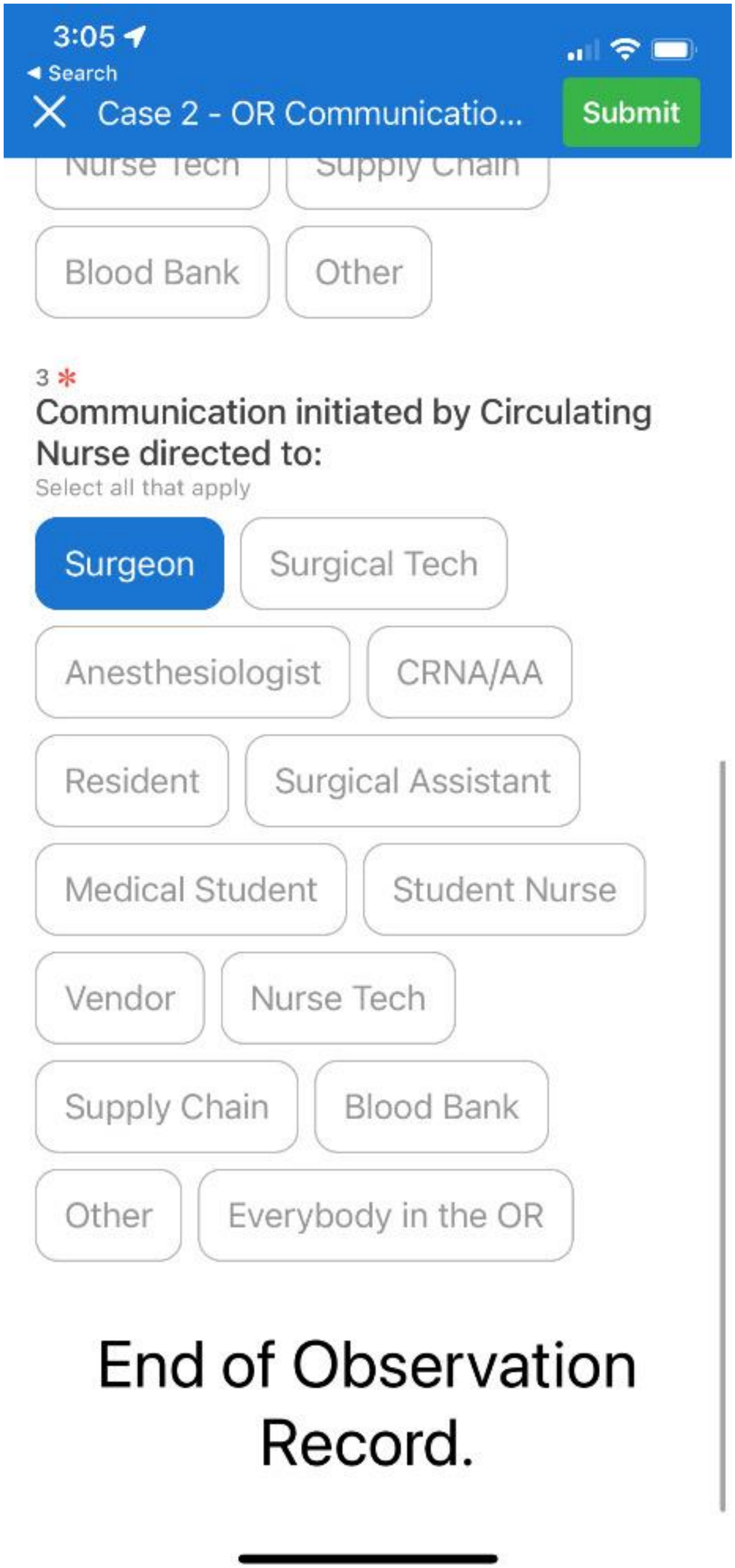
Search
Case 2 - OR Communicatio...
Submit
1 *
Type of Observation
Select 1
Instance of Communication
Additional Information or Other Notes


3:04
Search
Case 2 - OR Communicatio...
Submit
1 *
Type of Observation
Select 1
Instance of Communication
Additional Information or Other Notes
2 *
Instance of Communication Initiated by:
Select 1
Circulating Nurse
Surgeon
Surgical Tech
Anesthesiologist
CRNA/AA
Resident
Surgical Assistant
Medical Student
Student Nurse
Vendor
Nurse Tech
Supply Chain
Blood Bank
Other


3:05
Search
Case 2 - OR Communicatio...
Submit
2 *
Instance of Communication Initiated by:
Select 1
Circulating Nurse
Surgeon
Surgical Tech
Anesthesiologist
CRNA/AA
Resident
Surgical Assistant
Medical Student
Student Nurse
Vendor
Nurse Tech
Supply Chain
Blood Bank
Other
3 *
Communication initiated by Circulating Nurse directed to:
Select all that apply
Surgeon
Surgical Tech
Anesthesiologist
CRNA/AA
Resident
Surgical Assistant


3:05
Search
Case 2 - OR Communicatio...
Submit
Nurse Tech
Supply Chain
Blood Bank
Other
3 *
Communication initiated by Circulating Nurse directed to:
Select all that apply
Surgeon
Surgical Tech
Anesthesiologist
CRNA/AA
Resident
Surgical Assistant
Medical Student
Student Nurse
Vendor
Nurse Tech
Supply Chain
Blood Bank
Other
Everybody in the OR
End of Observation Record.

Appendix 3

Glossary of Social Network Terminology

Actors- persons in a network represented by the node

Nodes – the actors in the network seen as a small or larger *dot*. The more interactions that take place with the node, the larger to size of the *dot.*

Edges- the lines connecting the dots. These that represent *relationships*. The stronger the relationships, the thicker the line.

Directed edge- from one node to the other – starting and ending nodes [or, communication/interaction that has an identifiable starting and ending node]

Undirected edge- no identifiable starting or end node

Edge weight-the amount of times, based upon the number of interactions, that appear between the nodes.

Centrality- Measures used to quantify how important *nodes* are to the *network.*

Degree- the number of edges that a node has

Closeness- measures how well nodes connect together

Betweenness- is a way of detecting the amount of influence a node has over the flow of information in a graph. It is used to find nodes that serve as a bridge from one part of a graph to another.

Eigenvector- measures the level of influence of a node in a network

Network level measures-

Network size- number of nodes in a network

Density- A calculated measure indicating the connections between actors. It equals the number of edges divided by total possible edges an actor could have.

Hub- a node with many edges coming out of it

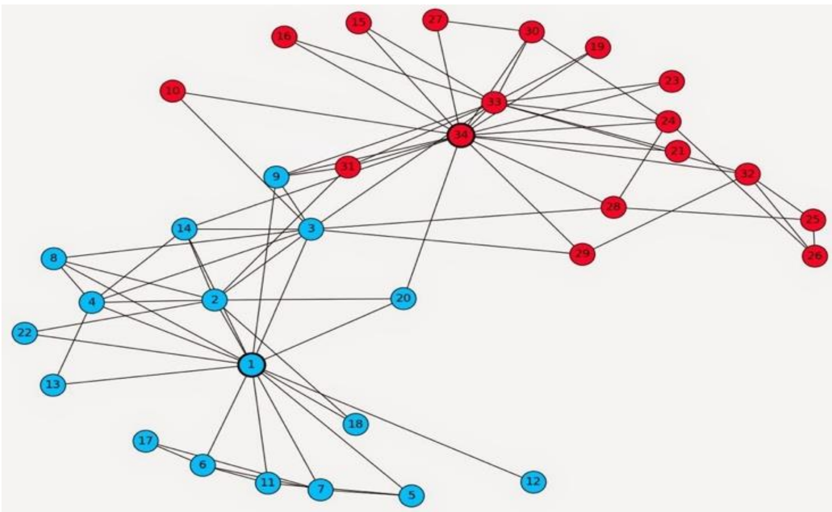
Authority- node with many edges pointing to it.

Dyad- two nodes that pair together

Cliques- when three or more nodes connect

For a better understanding, the Karate experiment will be used to better explain the concepts described above:

Karate experiment



{Zachary, 1977 #1295}

1. The nodes are represented by the colored dots
2. Edges are line connecting the nodes
3. This is a directed model – edges stop and start
4. There is no edge weight in this model
5. This graph includes all measures of centrality
    a. Degree- 34 different connections between the nodes

    b. Betweenness is represented by dots 9 and 31

    c. Closeness is seen in the red dots 33 and 34

6. Network size- 34 total nodes

    a. Density is a complex measure

    b. Nodes 1 and 34 are hubs

7. Nodes 1 and 34 have the most authority

8. Nodes 25 and 26 are dyads

9. 5, 7 11, 6 and 17 are a clique

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