



A Framework for Evaluating the Communication Dynamics of Surgical Teams, with a Major Military Medical Facilities

Hira Chishti, Ume Habiba, Umer Ehsan, Hassan Tariq, Tariq Usman

Noor Ul Ain (bsot-s22-025@superior.edu.pk) Department of Emerging Allied Health Technologies, Superior University, Lahore.

ABSTRACT

This research investigates the communication dynamics of surgical teams within a major military medical facility using social network analysis (SNA). Recognizing that effective communication is crucial for patient safety and team performance, the study employs an exploratory, prospective, and cross-sectional design to map and analyze interpersonal relationships within the operating room (OR). Data will be collected via sociometric surveys from clinicians across 13 surgical specialties in an 11-OR, 138-bed teaching hospital that performs over 11,000 annual procedures. The study will examine how OR culture, power dynamics, and interpersonal connections influence communication patterns. SNA metrics, including centrality measures, geodesic distance, network density, and centralization, will be used to evaluate individual, interpersonal, and group-level communication effectiveness. Regression analyses will assess the impact of team familiarity, size, and clinician composition on communication performance. The anticipated outcomes include identifying key network factors influencing communication, informing the development of targeted interventions to enhance team cohesion and operational efficiency, and potentially guiding the creation of improved perioperative staffing models. While acknowledging limitations related to the military setting's generalizability and the exclusion of purely supervisory roles, this research aims to provide novel insights into optimizing communication within the OR to improve patient safety and surgical outcomes.

Keywords: Operating Room Communication, Surgical Team Collaboration, Effective Communication, Surgical Process Improvement, Staff Communication.

Introduction

Healthcare systems strive for optimal patient outcomes through the provision of safe, timely, and patient centered care. Yet, the inherent complexity of clinical settings, particularly the operating room (OR), presents formidable obstacles to achieving this ideal. Patient safety is continually jeopardized by medical errors and adverse events, which can have devastating consequences. Studies in the United States have identified preventable medical errors as a leading cause of mortality, with estimates ranging from 200,000 to 400,000 deaths annually (James, 2013; Makary & Daniel, 2016). The OR, a domain where precision and coordinated action are vital, is especially vulnerable, as surgical adverse events account for a significant proportion of all adverse incidents within hospitals, approximately 66% (Zegers et al., 2011). These events, occurring in a notable percentage of hospital admissions (3.6%), can lead to substantial patient harm, including extended hospital stays, readmission, permanent disability, and mortality (Zegers et al., 2011). On a global scale, surgical safety issues contribute to half of all avoidable adverse events resulting in patient death or disability, totaling an estimated one million deaths each year (World Health Organization, 2009).

The efficiency and safety of surgical teams heavily depend on effective communication among members (Cvetic, 2011). A significant contributor to adverse events is the lack of proficiency in non-technical skills, such as teamwork and communication (Mazzocco et al., 2009). Team dynamics, including composition, familiarity, and size, play a crucial role in shaping team performance. Research indicates that team familiarity is associated with improved patient outcomes, such as reduced costs, fewer communication errors, lower error rates, and shorter operative durations (ElBardissi et al., 2008; Finnesgard et al., 2018; Flynn et al., 2018; Gillespie et al., 2012). Conversely, the size of the surgical team can influence OR efficiency, with studies showing that increasing team size can extend operative time, even when controlling for procedure complexity and patient status (He et al., 2014).

Communication within the OR is further complicated by socio-cultural factors. Power imbalances, hierarchical structures, and specific cultural contexts, such as those found in military settings, can create barriers to effective communication. Nurses, who are essential for patient advocacy and quality care, often face challenges in expressing concerns due to these hierarchical and social pressures (Wei et al., 2018; Raica, 2009; Morrow et al., 2016).

This research endeavors to explore the influence of OR culture, power dynamics, and interpersonal connections on communication patterns. Building on prior studies conducted in a military outpatient surgery context (Stucky, De Jong, & Kabo, 2020; Stucky, De Jong, Kabo, & Kasper, 2020), this investigation will employ social network analysis (SNA) to map and analyze the structure and effects of interpersonal relationships within the OR.

Literature Review

Social network analysis (SNA) offers a valuable tool for examining the complex network of relationships within social systems, including the OR. Unlike traditional research methods that focus on individual characteristics, SNA emphasizes the relationships between actors within a network (Scott, 2017). By quantifying the structural properties of social interactions, SNA can reveal patterns of information exchange and influence among individuals or groups (Borgatti et al., 2018). These properties can identify key influencers and highlight areas where communication or information flow is limited. A social network is comprised of individuals (nodes) connected by interpersonal relationships (ties), forming a complex, self-organizing system. These relationships are interdependent, with the surrounding structure affecting interactions. Ties can be directional (e.g., seeking advice) or non-directional (e.g., collaborating), and their strength varies based on the frequency of interaction and the resources exchanged (Borgatti et al., 2018).

Key SNA concepts include geodesic distance, which measures the shortest path between actors and indicates the efficiency of information flow (Borgatti et al., 2018). Shorter geodesic distances signify more efficient connections and faster information exchange. Centrality measures, such as degree, closeness, betweenness, and eigenvector centrality, reveal the relative importance of actors within the network. Degree centrality, reflecting the number of connections an actor has, indicates influence and access to resources (Borgatti et al., 2018). High degree suggests popularity or prestige, while high out degree implies knowledge dissemination (Borgatti et al., 2018). Closeness centrality measures an actor's direct or indirect connections, highlighting those who can rapidly communicate and distribute information. Betweenness centrality identifies actors who act as critical links between others, potentially controlling information flow (Scott, 2017; Borgatti et al., 2018). Eigenvector centrality indicates an actor's influence based on connections to other well-connected actors.

Network density and centralization are also critical measures. Density reflects the cohesion and interaction level within the network (Borgatti et al., 2018). High density indicates a tightly connected network, while low density suggests less interaction. Centralization reveals the distribution of power within the network. High centralization signifies a dominant actor, while low centralization indicates a more equitable distribution of influence.

Previous studies have demonstrated the utility of SNA in analyzing various social systems, including networks of terrorists, providing insights into information flow and influence (Krebs, 2002). In the context of the OR, understanding these network dynamics can illuminate how communication patterns affect patient safety and team performance. This research aims to employ SNA to characterize the network factors influencing clinician communication effectiveness in the OR, focusing on individual, interpersonal, and group levels, and examining the impact of power dynamics. Furthermore, it will investigate how team structure, including familiarity, size, and clinician composition, influences communication effectiveness.

Research Methodology

To thoroughly investigate the intricate communication patterns within the surgical operating room, this research will utilize an exploratory, prospective, and cross-sectional study design, with a specific focus on network analysis. This methodology is chosen to capture a snapshot of the dynamic interactions and relationships among healthcare professionals at a single point in time, while also allowing for the exploration of emerging patterns. Crucially, the U.S. Army Regional Health Command–Atlantic Institutional Review Board has rigorously reviewed and approved this study, ensuring that it adheres to the highest ethical standards and poses minimal risk to all participants involved. This approval underscores the study's commitment to safeguarding participant well-being while generating valuable insights.

1• Setting and Participant Selection

The research will be conducted within an 11-operating-room (OR) facility at a 138-bed military medical center. This center facilitates over 11,000 surgical procedures annually, encompassing 13 surgical specialties. As a teaching hospital, it supports medical residency programs and practical training in perioperative nursing, surgical technology, and nurse anesthesia. A total population sampling strategy will

be used to recruit all eligible clinicians. For network studies, sample size depends on the network's overall size and participation rate; a response rate of 70% or higher is generally considered sufficient for accurate estimations (Kossinets, 2006). To ensure robust data, we aim to recruit 80% of the network. Inclusion criteria involve active duty, reserve, or National Guard military personnel, as well as federal employees or contractors (including students and residents), who are 18 years or older, proficient in English, and directly involved in surgical patient care. Clinicians in purely supervisory roles, without direct patient contact, will be excluded.

2• Study Instrument

A sociometric network survey, developed based on prior network studies and validated for content (Kabo, 2016), will serve as the primary data collection instrument. The survey's design is informed by our theoretical framework, literature review, and expert consultation. A pilot study was conducted to assess question clarity, sensitivity, participant burden, and cognitive demand. The survey will yield six relational networks.

3• Demographic and Individual Measures

Participants will provide demographic data upon enrollment, including gender, race, clinician type, years of clinical and facility experience, work frequency, military or federal status, and military rank or federal civil service pay grade. www.x-mol.com

4• Recruitment Procedures

Participants will be recruited using non-coercive methods such as promotional materials, informational sessions, and word-of-mouth. Individuals not initially consenting during the recruitment phase may be approached on the day of surgery. Voluntary informed consent will be obtained privately to minimize potential coercion or group influence. All individual and digital data will be linked to unique participant identification numbers to ensure privacy and confidentiality.

5• Data Collection Procedures

A six-month data collection plan, based on our prior research, will be implemented. Data will be collected through the demographic form and the sociometric network survey. To reduce respondent burden and enhance survey efficiency, a random number generator will be used to select a maximum of five surgical teams daily. Data collection will occur at the end of the last surgical case to avoid disrupting OR productivity metrics, such as turnover times and surgical utilization. The electronic survey will be administered to each participant via a study tablet immediately following the conclusion of their last case. This method mitigates biases and recall errors associated with retrospective data collection. Participants appearing on multiple surgical teams will be surveyed each time, contributing to the overall response rate. Data collection will cease once 80% of the network has been surveyed at least three times. Data will be collected during normal working hours and will focus on non-emergent cases, as trauma cases introduce variability that could confound data.

4. Results/Analysis

1. Analytical Procedures

Statistical analyses and regression modeling will be conducted using STATA SE/14(Kossinets, 200G). Social network data will be processed with UCINET 6.660, and network visualizations will be generated using Net Draw. Initial data inspection will involve descriptive statistics and Shapiro-Wilk tests to assess data distribution. For data exhibiting approximate normality, Pearson's correlation coefficients and 95% confidence intervals (CIs) will be employed. In cases of non-normally distributed data, Spearman's rank order correlation will be used.

2 Evaluation of Communication Performance

Two distinct assessments of communication performance will be developed for each participant: a task specific rating and a general communication effectiveness rating. These ratings will be derived from peer evaluations within the network(Kossinets, 200G). We hypothesize that these two communication dimensions are fundamentally different. Participants will be assigned ordinal communication performance scores (1–5). Additionally, a team-level communication performance score will be calculated by averaging individual scores, enabling the identification of teams with varying communication effectiveness.

3 Examining Network Determinants of Communication Efficacy

Objective 1: Network Factors Shaping Clinician Communication Effectiveness Objective 1 of this study is designed to comprehensively explore the network factors that influence clinician communication effectiveness within the operating room (OR) environment. This will be achieved by constructing six distinct relational networks derived from the sociometric survey, subsequently employing social network analysis (SNA) metrics to elucidate the intricate communication patterns.

Individual-Level Examination At the individual level, the focus is to determine the relationship between an individual's network connections and their perceived communication performance. To this end, correlations between network variables and communication performance ratings will be computed. Specifically, Pearson's correlation coefficients will be utilized to assess the association between centrality measures, such as degree, closeness, betweenness, and eigenvector centrality, and communication performance ratings(Kossinets, 200G). Furthermore, regression analyses will be conducted to identify predictors of communication performance. Multiple linear regression models will be constructed, with communication performance ratings serving as the dependent variable. Demographic characteristics, including age, gender, experience, and role, alongside network centrality measures, will be incorporated as independent variables. To ensure the robustness of the regression models, diagnostic measures and graphical displays will be generated. These tools will facilitate the assessment of multicollinearity, detect deviations from model assumptions (e.g., linearity, normality, homogeneity of variance), and quantify the influence of potential outliers. Finally, parameter estimates, along with 95% confidence intervals (CIs) and p-values, will be reported for the final model, providing a detailed understanding of individual-level influences on communication effectiveness.

Interpersonal-Level Examination Moving to the interpersonal level, this examination recognizes the interdependent nature of actors within dyadic networks. Given this interdependence, statistical methods robust to violations of independence assumptions will be employed. Specifically, geodesic distance, representing the shortest path between two individuals, will be used to predict team member network position. Its relationship to pairwise communication performance will be evaluated using permutation- based quadratic assignment procedures (QAPs). Additionally, multiple regression QAPs will be used to

assess the impact of multiple independent variables, including demographic variables and network indicators, on dyadic communication performance differences(Kossinets, 200G). To control for dyad- specific effects across time, a partitioning variable will be incorporated. Results will be presented as QAP correlation coefficients and multiple regression QAP results with p-values, offering insights into the influence of interpersonal relationships on communication effectiveness.

Group-Level Examination : Finally, at the group level, the study aims to determine the strength of the linear association between network density and centralization and team-level communication performance ratings. Pearson product-moment correlation coefficients will be used for this purpose. Furthermore, multiple linear regression models will be developed to identify predictors of team-level communication performance. In these models, network communication performance will serve as the dependent variable, while density and centralization, considered separately, will act as predictor variables. Estimated coefficients, 95% CIs, p-values, and measures of variable importance will be reported, providing a comprehensive understanding of how group-level network properties influence team communication effectiveness. This analysis will shed light on the structural factors that contribute to or hinder effective communication within surgical teams.

Assessing the Impact of Team Composition In pursuit of Objective 2, this research will utilize regression analyses to meticulously examine the impact of surgical team familiarity, team size, and clinician composition, specifically the presence of students or residents, on the mean team-level communication performance scores. The primary aim is to quantify how these structural factors influence communication effectiveness within the operating room (OR). To ascertain the statistical significance of the observed effects, p-values will be employed, providing a rigorous assessment of the relationships under investigation. Furthermore, recognizing the potential for non-independence due to clinicians' involvement in multiple OR teams, sensitivity analyses will be conducted using multilevel modeling. This sophisticated approach will allow for a thorough evaluation of potential violations of independence assumptions, ensuring the robustness and reliability of the study's findings. By employing these analytical strategies, the research seeks to provide a comprehensive understanding of how team structure shapes communication dynamics within the OR, ultimately contributing to improved patient safety and operational efficiency.

Discussion

The occurrence of adverse medical events poses a significant threat to optimal patient outcomes, representing a pressing public health concern. To address this, the enhancement of healthcare quality and the minimization of patient harm are paramount, necessitating a deep understanding of effective communication. This research is designed to illuminate the complex interplay between interpersonal relationships, team structure, and communication effectiveness within surgical teams. It is anticipated that the innovative design of this study will yield valuable insights into the dynamics of surgical team communication, thereby informing strategies for quality and safety improvements. Furthermore, the findings are expected to guide the development of targeted interventions aimed at fostering cohesive surgical teams, enhancing operational efficiency, and mitigating communication deficits within the operating room (OR). The potential implications of this research extend to the creation of novel perioperative staffing models, which would consider the influence of team familiarity and past team performance on critical surgical metrics. Additionally, this study aims to identify strategies for promoting healthier work environments for nurses, recognizing their pivotal role in patient care.

However, it is essential to acknowledge several limitations that may influence the interpretation and application of this study's findings. Firstly, the study's setting within a military medical center, characterized by unique demographic and cultural contexts, may limit the generalizability of the results to civilian healthcare settings. Secondly, despite the utilization of total population sampling, the exclusion of clinicians in supervisory roles, who often hold influential network positions, could potentially affect the comprehensive understanding of communication dynamics within the OR. While nurses are widely recognized as highly trusted professionals, playing a crucial role in patient safety and healthcare improvement (Reinhart, 2020), their ability to communicate and collaborate effectively with inter professional team members is often constrained by hierarchical structures and cultural norms.

Consequently, the relational networks developed through this study will reveal critical cultural aspects of nurses' status and position within surgical teams, offering valuable insights into their collaboration and communication with the broader inter professional surgical team. This understanding is crucial for developing interventions that support and empower nurses, thereby improving overall patient safety and team effectiveness.

Conclusion

This research embarks on a pioneering endeavor, employing social network analysis (SNA) to meticulously dissect the complex web of communication within the operating room (OR). Recognizing that effective communication among OR clinicians stands as a cornerstone for enhancing surgical outcomes, minimizing the occurrence of medical errors, and fostering optimized surgical team performance, this study aims to unravel the intricate dynamics at play.

By meticulously mapping and analyzing the relationships and structural team properties that shape OR communication, this research seeks to generate unprecedented insights. These findings will not only illuminate the critical factors influencing communication efficacy but also provide invaluable guidance for refining surgical staffing models and constructing high-performing perioperative teams. Ultimately, this study's contributions will advance our understanding of how to cultivate a communication-rich environment within the OR, leading to tangible improvements in patient safety and surgical efficiency.

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