Leadership During Action Team Formation: The Influence of Shared Leadership Among Team Members During the Perioperative Process

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ABSTRACT

There are many leadership theories that dominate the field of Industrial and Organizational Psychology, however there is a lack of understanding as to which leadership processes may be most appropriate for action teams in high stress environments. Previous research has articulated leadership behaviors, but has largely ignored the temporal processes of leadership, and how it changes throughout the operating team's tenure. The proposed study investigates two types of leadership, namely shared and autocratic leadership, that take place during critical steps of the perioperative process and relates these leadership behaviors to team dynamics and psychological processes. Specifically, this study builds upon other studies by testing how leadership behaviors are related to levels of psychological safety and the optimization of teamwork and communication among team members. We were also interested in understanding if the surgeon's perception of past performance of their team has an impact on the amount of trust the leader has in his/her team and if this in turn, has an impact on the type of leadership utilized during the team's tenure. As an exemplar environment, we explored these dynamics in the operating theater, which is a high stakes environment requiring both technical and non-technical skills, such as leadership, communication, and teamwork. Results show that the correlation between the surgeon's perceived past performance of the team and the trust the surgeon has in his/her team and the relationship between team's trust and teamwork and communication were significant at the alpha =.1 level. All other relationships were non-significant.

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GENERAL AUDIENCE ABSTRACT

In the field of Industrial and Organizational Psychology, many leadership theories have been developed, however there is a lack of understanding as to which type of leadership is best for teams who work in high-stress environments, such as the operating room. This study looks at two types of leadership: shared leadership and autocratic leadership. Shared leadership is when all team members emerge and have a leadership role, whereas autocratic leadership is when one person makes all the decisions without consulting other team members. Previous research has articulated leadership behaviors, but has largely ignored the temporal processes of leadership, and how it changes over time throughout the surgical procedure. This study builds upon other studies by testing how leadership behaviors are related to levels of psychological safety and the optimization of teamwork and communication among team members. We were also interested in understanding if the surgeon's perception of past performance of their team has an impact on the amount of trust the leader has in his/her team and if this in turn, has an impact on the type of leadership utilized during the team's tenure. As an exemplar environment, we explored these dynamics in the operating theater, which is a high stakes environment requiring both technical and non-technical skills, such as leadership, communication, and teamwork. Results show that the relationship between the surgeon's perceived past performance of the team and the trust the surgeon has in his/her team is significant and the relationship between the trust the surgical team members have in each other and the amount that they communicate with each other is also significant.

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1 Introduction

The World Health Organization (WHO) has estimated that 234 million major surgical procedures occur every year with a complication rate of 7 million and a death rate of 1 million people per year (Weiser, et al., 2008). Donaldson, Corrigan, and Kohn, (2000) in their seminal book *To Err is Human* have established that 98,000 patients are harmed by medical error each year. That number has increased since: in the period between 2000 and 2002 estimates soared to 575,000, which is about 195,000 deaths per year (Makary & Daniel, 2016).

Agha, Fowler, and Sevdalis (2015) have shown through a review that healthcare professionals go through extensive training to obtain adequate technical skills; however, increasing evidence has shown that harm to patients is not entirely due to technical skills. For example, the Scottish Audit of Surgical Mortality found that technical errors accounted for 4.3% with more errors attributed to poor decision making (Agha et al., 2015). Performance in the operating room (OR) depends on both technical and non-technical skills. Non-technical skills include teamwork, communication, situational awareness, and decision making and good performing surgeons use non-technical skills as an integral part of their behavior (Yule et al., 2008). Poor non-technical skills have been identified as being the cause of adverse events in settings such as the operating room (Gawande, Zinner, Studdert, & Brennan, 2003; Rogers et al., 2006; Greenberg et al., 2007; Lingard et al., 2004). Non-technical skills scales have been first designed to be used in the aviation industry (Flin, Martin, Goeters et al., 2003) and then have been explored in surgery (Sevdalis et al., 2008) with the Non-Technical Skills (NOTECHS) (Sevdalis et al., 2008) and the Observational Teamwork Assessment for Surgery (OTAS) (Healey, Undre & Vincent, 2004). These scales have examined the non-technical skills of the team. There are also individual non-technical skills scales such as the Non-technical Skills for

Surgeon (NOTSS) (Flin, Yule, Paterson-Brown, Maran, 2006), the Anesthetist's Non-Technical Skills (ANTS) (Fletcher et al., 2003) and the Scrub Practitioners' List of Intraoperative Non-Technical Skills (SPLINTS) (Mitchell et al., 2012).

The value of non-technical skills has gained increasing attention over the years and Industrial and Organizational Psychology researchers have provided excellent studies for us to learn from. In fact, non-technical skills have been studied in both the organizational setting and in the operating room. In the organizational setting, non-technical skills have been studied in relation to workplace procedures (Thorogood & Crichton, 2013), virtual teams (Hoch & Kozlowski, 2014), well-being and job satisfaction (Mathieu, Neumann, Hare & Babiak, 2014) and crisis management (Uitdewilligen & Waller, 2018). In the operating room setting, many scales have been developed to capture these skills (Ceschi, Costantini, Zagarese, Avi, & Sartori, 2019; Mishra, Catchpole, Hirst, Dale, & Mcculloch, 2017; Hull, Arora, Kassab, Kneebone, Sevdalis, 2011; Parker, Flin, Mckinley, & Yule, 2013; Yule et al., 2008) and related these skills to performance (Yule et al., 2015), miscommunications and interruptions (Gillespie et al., 2017).

In the present study we will be discussing the non-technical skills of communication, teamwork, and leadership. These non-technical skills have been explored due to their impact on surgical outcomes. Failure in communication has been documented to be the cause of malpractice claims 24% of the time (Rogers et al., 2006). Failure in teamwork has shown to contribute to adverse events (Burtscher & Manser, 2012; Gawande et al., 2003; Greenberg, Regenbogen, & Studdert, 2007; Lingard, Espin, Whyte, 2004; Rogers et al., 2006). Leadership in action teams has been the focus of multiple studies in healthcare (Hunziker et al., 2011; Parker, Yule, Flin, & Mckinley, 2012; Parker, Flin, Mckinley, & Yule, 2014; Hu et al., 2016; Rydenfalt, Johansson, Odenrick, Akerman & Larsson, 2015) and has been found to be a medium for

functioning communication and a key component for teamwork. Surgical teams find themselves in situations of uncertainty that is inherent to surgery. The appointed leader, the surgeon, must demonstrate leadership behaviors that are inducive to communication and teamwork to maximize patient safety and performance (Rydenfalt et al., 2015). Leader effectiveness is important for the team's ability to develop and learn and this process may be facilitated by a psychological safe environment (Singer, Hayes, Gray, & Kiang, 2015).

Research on hierarchical teams has shown that power disparities lead to a decrease in psychological safety among team members, especially those who are learners (Edmondson, Higgins, Singer, & Weiner, 2016). Psychological safety is represents the perception one holds of the work and social environment rather than the perception of the tasks related to the job (Frazier, Fainshmidt, Linger, Pezeshkan, Vracheva, 2017). It is the perceived threat of embarrassment or professional and social repercussion when one exposes their vulnerabilities. It has been shown that an increase in psychological safety may contribute to learning and speaking up behaviors (Singer et al., 2015).

In the present study we will examine in what capacity the non-technical skills of communication, teamwork and leadership, relate to each other, to psychological safety, to performance and to the level of trust among the team. We are also interested in understanding if there is a relationship between the amount of trust the surgeon has in his/her team and the type of leadership utilized to guide the team towards optimal performance.

Given the gaps in safety and safe performance demonstrated in healthcare (particularly the OR), and the high stress context of work, we have chosen the OR as our area of focus. OR teams have been chosen because of the hierarchical attribute they possess, and the high-stake risks associated with their work. Surgical teams are unique because team members have different

specializations, which gives the teams a multidisciplinary attribute. Team members are familiar with each other, however there is an *ad hoc* component and a short-lived life span of each team. Professional norms in this sector have created barriers to speaking up behaviors and asking for help or guidance. However, speaking freely if one notices something wrong may impact the patient's safety.

There are many studies that look at the relationship between leadership and the psycho-social constructs discussed above, however, the novelty of this study is that we are examining the flow of leadership interactions in a temporal manner throughout the perioperative process. Interactions of five critical moments of the surgical procedure will be computed through a social network that will be used to determine the type of leadership used among the team. Social network measures of the overall surgical procedure will be used to determine the type of leadership employed by team members, however, as an exploratory addition, the temporal flow of leadership will be included. To our knowledge, the study of leadership examined in a temporal fashion paired with a social network analysis has never been done before. We postulate that a well-developed network enables knowledge of available expertise among the team members and can enhance the shared leadership process which can foster a climate of trust, psychological safety and enhanced communication resulting in greater performance.

In the following sections, we will be discussing the constructs taken into consideration in this study through a literature review, the proposed model based on the findings of the published literature, the measures utilized for each construct, followed by the analysis and results and concluding thoughts.

1.1 Literature Review

1.1.1 Shared Leadership

Leadership theories have dominated organizational psychology research in the past few decades. Some authors regard leadership as a defined position of authority, others see leadership as a behavior that can be shared among all team members (Mazzocco et al., 2009). Shared leadership is defined as a "simultaneous, ongoing, mutual influence process within a team that is characterized by serial emergence of an official as well as unofficial leader" (Pearce, 2004). In this process, all team members are fully engaged in leadership behaviors and are leading one another. It is defined as a dynamic process because it occurs when there is the need for a team member to take on a leader's role. That is, the person with the adequate skills for that situation will be the one who will take on a leadership position (Friedrich, Vessey, Schuelke, Ruark, & Mumford, 2011). Action teams, such as surgical teams, work under stressful conditions and the need for someone to take over leadership and guide them towards shared goals is crucial. These teams are multidisciplinary; thus, each team member brings unique technical skills and emerges when called upon to deliver their expertise.

In fact, results from a study conducted by Carmeli and Schaubroeck (2006) showed that having multiple leaders in the team is not sufficient for performance, but rather behavioral integration, such as information exchange, increases performance (Carmeli and Schaubroeck, 2006). On the same note, Mazzocco and colleagues (2009) have shown that shared leadership behaviors, namely information sharing during intraoperative and handoff phases as well as briefings during hand off phases are determinants in the decrease of the probability of death in the healthcare setting (Mazzocco et al., 2009). Other research with anesthesia teams has shown that high performing teams were endowed with shared leadership among residents and nurses,

whereas in low performing teams, residents held most of the leadership (Kunzle et al., 2010). Furthermore, shared leadership, or distributed leadership as they define it, is associated with patient safety behaviors (Rydenfalt et al., 2015).

Situational awareness of time-critical information is delivered by the dialogue among team members of the clinical decisions to be made (Gillespie, Gwinner, Fairweather & Chaboyer, 2013). Not only is it important for individuals to have situational awareness for their own performance but it is crucial for the team to collectively be situationally aware (Wright & Endsley, 2008). Shared leadership enables team members to have a shared mental model of the situation, which helps team members adapt and coordinate based on the knowledge each individual has of the current situation (Mathieu, Heffner, Goodwin, Salas, Cannon-Bowers, 2000). In a perioperative setting, professionals that have different responsibilities regarding the patient, need to act as a team and transfer information to one another effectively. The psychological mechanisms behind shared leadership allows for a shared mental model facilitating the transfer of information and allowing for situational awareness of non-routine events that may put the patient at risk.

1.1.2 Autocratic Leadership

Autocratic leadership has a negative connotation to it; however, it is highly context dependent. Historically, autocratic leadership has been defined as "being arbitrary, controlling, power oriented, coercive punitive and close-minded" (Bass, 2008). This type of behavior is not typically tolerated in western society, but there are still subtle ways in which these behaviors may arise. An autocratic leader monopolizes information and makes decisions without discussing critical issues, thereby leaving the team without information to make a collective decision (Vroom and Jago, 1988). Vroom and Jago found that managers need to identify situational

demands and act accordingly by deciding whether to enact a participative leadership behavior or an autocratic one (Vroom & Jago, 1988). Although most evidence points towards an increase of communication when employing a shared leadership approach, there is evidence that shows that an autocratic style may be more appropriate in some situations, such has when there is a time constraint (Yun, Faraj & Sims, 2005).

These theories have been validated by recent research with regards to action teams. Yun and colleagues (2005) demonstrated that there are two types of leadership behaviors in action teams: those that takes complete control over the situation and expect the team to carry out the plan as told, and behaviors that prompt team members to discuss and take part of the decision making process. The authors found that surgeons engage in both behaviors, depending on the situation. When the team members have access to information that is useful for the team then a shared leadership approach is taken, whereas when the situation is time sensitive, then an autocratic approach is taken (Yun et al., 2005).

Based on this evidence, we argue that if an autocratic approach is taken, less information is shared, and this will influence team dynamics such as communication and psychological safety throughout the surgery.

1.1.3 Psychological Safety

Psychological safety as defined by Edmondson (2003) describes the "individuals' perceptions about the consequences of interpersonal risks in their work environment" (p.4). It represents an individual's evaluation of the potential interpersonal repercussions when engaging in a behavior that puts that individual on the line, such as when reporting a mistake, proposing a new idea or asking a question (Edmondson, 2003). Psychological safety can, not only be an individual level phenomenon, but it can also be a shared sentiment among a team. In fact,

Edmondson (1999) defines it as “a shared belief held by members of a team that the team is safe for interpersonal risk taking” (Edmondson, 1999). Psychological safety has been especially studied in environments where the difficulty to speak up is prevalent and such environments and organizations are usually characterized by a strong hierarchical structure.

Previous research has shown that higher status professionals experience higher psychological safety and leader inclusiveness is associated with psychological safety (Nembhard & Edmondson, 2006). Leader inclusiveness is defined as behaviors that directly invite and appreciate speaking up behavior from other team members. Edmondson and colleagues (2016) showed that in the education and healthcare fields, leader effectiveness can contribute to a psychologically safe environment fostering the ability for team members to grow and learn. We believe that these behaviors are attributes of a shared leadership approach. Challenging the status quo and raising questions when the stakes are undoubtedly high is an important element in surgical team.

Previous studies conducted by Edmondson (1999) showed that psychological safety is positively correlated with learning behaviors, with learning behaviors mediating the relationship between psychological safety and performance. Thus, psychological safety is not only the result of leader inclusiveness, but it is also an antecedent to learning and performance (Edmondson, 1999).

Surgical teams are action teams that often deal with stressful situations. These teams are inherently multidisciplinary and strongly hierarchical. Team members may have different viewpoints but are hesitant to divulge them because of the risk of being wrong and damaging their reputation, especially when it comes to challenging higher status professionals (Edmondson, 1999). Status differences create counterproductive communication patterns which

are responsible for medical errors that could have been easily prevented (Institute of Medicine, 2003). In fact, hierarchical dynamics can create a lack of a safe space to speak up, whereas the confidence in other team members appears to be important for establishing a psychologically safe environment (Aveling et al., 2018).

Furthermore, the professional role of a surgeon is seen to have autonomy and therefore criticism from colleagues are often unwarranted and infrequent, limiting the spread of knowledge of best practices or inadequate skills or behaviors (Gaba, 2001). Not only does this phenomenon takes place among low status professionals versus high status professionals but it also occurs among the same status professionals. Singer and colleagues (2009) showed that, because of the autonomy physicians are expected to have, speaking up and asking for help when unsure does not take place as frequently as it should among physicians.

Setting the stage through leadership for a psychologically safe environment to enable all team members to speak up and grow professionally is something that is manageable, unlike other unfortunate events that surgical teams have no control over, such as patient acuity.

Leader inclusiveness is associated with psychological safety because it fosters an environment where people feel comfortable to speak up, this may increase effective communication and teamwork because team members are on the same page. It appears that trust is positively associated with psychological safety (May, Gilson & Harter, 2004). Although psychological safety and trust are highly related constructs -both are intrapsychic states that deal with vulnerability- they are conceptualized as different from one another: trust is concerned with *others* while psychological safety is concerned with the *self* (Edmondson, 2003).

1.1.4 Trust

Trust is especially important in environments where close cooperation, teamwork and group participation and contribution are required (Salas, Sims, & Burke, 2005). Teams belong to a multilevel environment where trust has been increasingly conceptualized as a shared construct that transcends the individual level.

Trust can be defined as "a willingness to accept vulnerability based on positive expectations of trustworthiness" (Mayer, Davis, & Schoorman, 1995; Rousseau, Sitkin, Burt, & Camerer, 1998). When one is willing to accept vulnerability there is an uncertainty within an assumption of how one's actions will have a beneficial outcome for the self. Positive expectation of trustworthiness is the perception and belief of the trustee(s) (Costa, Fulmer & Anderson, 2017).

The literature has described two types of trust: affective and cognitive trust. Affective-based trust refers to a sentimental connection where there is an emotional investment (Lewis & Weigert, 1985). Cognitive-based trust refers to the trustee's reliability, competence, and dependability (Luhmann, 1979). In this study we are concerned with the latter. The focus of this research is to understand the dynamics of the collective trust the team members have in each other and the trust the leader may have in the team.

Collective team trust: collective team trust is the aggregated perception team members have about their own trust in the team (Fulmer & Gelfand, 2011). Team trust is the result of the consensus among members of the team about their trust in the team. It is therefore important that there is a within-team consensus to aggregate the individual trust to collective trust (Kozlowski & Klein, 2000).

Individual trust in teams: There is a gap in the literature on the impact of the individual's trust in teams (Fulmer & Gelfand, 2011). In this study we are interested in filling that gap by understanding the impact of the leader's (i.e. the surgeon's) trust in the team (i.e. surgical team) and if this has any effects on the type of leadership employed and the psychological processes of the team.

In their literature review, Costa and colleagues (2017) report that team trust has been shown to increase knowledge sharing (Szulanski, Cappetta & Jensen, 2004) and enhance a climate of psychological safety (Edmondson, 1999). Recent meta-analysis has shown that there is a positive relationship between team trust and performance (De Jong, Dirks, & Gillespie, 2016) especially when team members' skills are different from each other's and there is a need for interdependence.

Surgical teams are multidisciplinary teams, where team members change day to day. The designated leader is the surgeon; however, trust levels may differ based on personal disposition or because of the frequency and familiarity of working with a team. It is therefore important to understand if the team member trust and the trust the leader has in the team has an effect on outcomes such as performance, teamwork, communication, psychological safety and the type of leadership used throughout the procedure.

1.1.5 Social Network Analysis

Social network analysis is a powerful method that can examine the inner structures of groups. Researchers have started to pay attention on how social structures play a role in teamwork. Network measures, such as centrality, centralization and network density have been factors in work satisfaction, performance, and power (Yang & Tang, 2004). Specifically, there is evidence that network factors can have an effect on team communication (Lee, Bachrach &

Lewis, 2014; Reagans & Zuckerman, 2001), workflow networks (Troster, Mehra, & Van Knippenberg, 2014) job-related perceptions (Ibarra & Andrews, 1993), perceived intergroup conflicts (Labianca, Brass, & Gray, 1998), individual performance (Lucius & Kuhnert, 1995) and group performance (Sparrowe, Liden, Wayne, Kraimer, 2001). Researchers have used network measures as an alternative to aggregated measures when it comes to team-level constructs (Carson, Tesluk & Marrone, 2007; Chiu, Owen & Tesluk, 2016). With the use of social network analysis, it is possible to gain a deeper understanding of the surgical team processes and the emergent states.

The most common measures used by researchers are density and centralization. Wasserman & Faust (1994) define density as the total amount of construct within a team and centralization as a measure of equality regarding the number of incoming ties. However, these two measures lack to consider the degree to which ties come from a well-connected node (Lemoine, Koseoglu, Ghahremani & Blum, 2020). In hierarchical teams, such as surgical teams, it can be very useful to have that information incorporated into the measures used. For example, an interaction coming from a well-connected team member can have enhanced value, therefore that interaction may be affected by the position or status of the team member (Lemoine, et al., 2020). In the case of this study, the hierarchical nature of the teams should be reflected in the ties of the social network for it to be more representative of the observed interactions.

From a shared leadership perspective, density is the "extent to which leadership influence is distributed among a relatively high or relatively low proportion of group members" (Carson et al., 2007 p. 1220). Centralization, from a shared leadership perspective, is "the range or variability of the individual actor indices" (Wasserman & Faust, 1994, p. 180). Scholars have taken the measure of density and centrality and used them interchangeably to measure shared

leadership (Nicolaides et al., 2014**;** Wang et al., 2014**)** however, it is questionable if these measures adequately operationalize shared leadership (Lemoine et al., 2020). Density is the overall level of ties within a network and decentralization is the spread of these ties among group members. Therefore, density is the "total amount of emergent resources (e.g. leadership) within a group" and decentralization is "a measure of the group's leadership status equality" (Lemoine et al., 2020 p. 436). Both these measures are important and give insight into the mechanism of the social network, but they are distinct. Lemoine and colleagues (2020) have proposed an alternative network measure, the Importance Weighted Density (IWD). The IWD measure is the average of the individual importance-weighted scores (IWS). The IWS takes into account the scaled incoming tie from member *j* to member *i,* where *j* represents every group member other than *i*, the in-degree centrality for member *j*, the maximum in-degree centrality within the group, the largest possible scaled matrix score and the largest in-degree centrality within the matrix. The formula used to calculate the IWS is similar to the centralization formula, however, the IWS takes into account the relative centrality of a member sending a link to the focal member. As such, the centrality is a weighting factor for the ties that emerge from member *j* who are more central in the network. Density is the proportion of the overall number of ties for members in a group and the total number of possible ties. The IWD formula does still capture this relationship but it multiplies it by the scaled incoming tie from *j* to *i,* thus taking into account the relative centrality (or importance) of the member sending the link and the team's size. The average of the IWS, the IWD, will be used to determine the type of leadership used by the surgical teams. Higher IWD indicate a shared type of leadership approach whereas lower IWD values indicate a more autocratic leadership approach relative to the sample.

1.2 Research Question

The literature shows that some leadership functions may be best performed by the designated leader (i.e. the surgeon) who is appointed by the system to have the final say (Cooper and Wakelam, 1999; Lloyd et al., 2001; Meerabeau and Page, 1999; Thilo, 2005), whereas other functions are best performed when leadership is shared (Flin et al., 2003; Klein, Ziegert, Knight, & Xiao, 2006; Xiao, Seagull, Mackenzie, & Klein, 2004). Therefore, both types of leadership are important in healthcare teams (Kunzle, Kolbe & Grote, 2010).

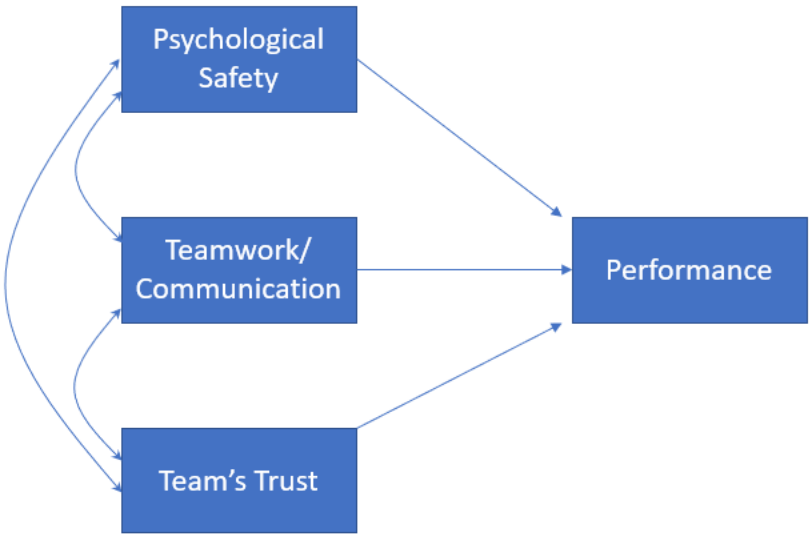
Shared leadership approach may allow team members to serially emerge to speak up freely as they are invited to take on a position of leadership and guide each other towards shared goals. Shared leadership may facilitate psychological safety and learning. It may also facilitate team behaviors such as teamwork, communication, and team's trust. The perioperative process has different phases that require more or less interaction between specific team members, and therefore leadership behaviors may change throughout the procedure yielding a temporal component to the measure of leadership. Given that there is no previous research of the temporal flow of leadership in the specific context of the OR examining these constructs, our research questions are explorative.

Model 1:

1. In an action team, is there a relationship between team's trust and psychological safety, teamwork/communication, and performance? (Figure 1)
2. In an action team, is there a relationship between psychological safety and team's trust, teamwork/communication, and performance? (Figure 1)
3. In an action team, is there a relationship between teamwork/communication and psychological safety, team's trust and performance? (Figure 1)

Figure 1

Model 1



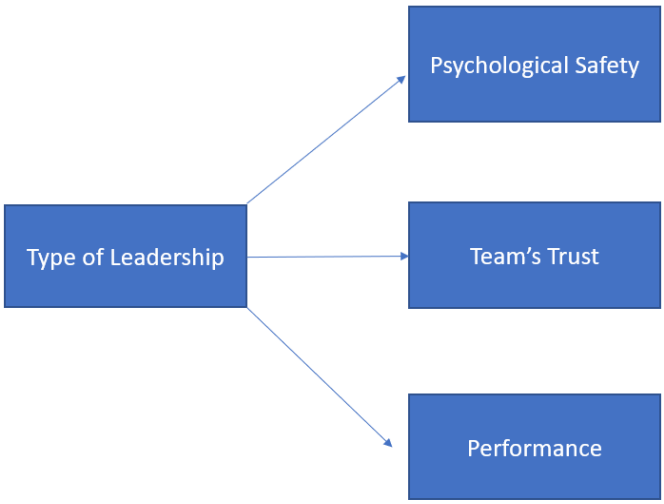
Note. Figure 1 shows the construct diagram for the exploratory relationship between teamwork/communication, team trust, psychological safety, and performance.

Model 2:

4. In an action team is there a relationship between the type of leadership employed and team trust, psychological safety, and performance? (Figure 2)

Figure 2

Model 2



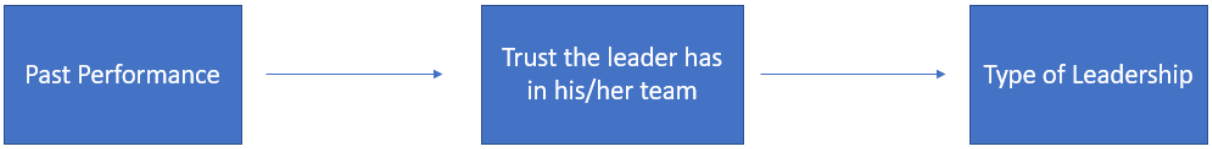
Note. Figure 2 shows the construct diagram for the exploratory relationships between types of leadership (autocratic or shared) with psychological safety, team trust, and performance.

Model 3:

5. Does the surgeon's perception of past performance of the team predict the amount of trust the surgeon has in his/her team? (Figure 3)
6. Does trust the surgeon has in his/her team have a relationship with type of leadership used? (Figure 3)

Figure 3

Model 3



Note. Figure 3 shows the construct diagram for the exploratory relationship of the surgeon's perceived past performance of the team with trust the leader has in his/her team and the relationship with the type of leadership (autocratic or shared) utilized during the surgical procedure.

The literature points towards a relationship between most of these constructs; however, the goal of this study is to understand if there is a relationship in a context where stress levels are exacerbated by unforeseen events and where communication breakdown may have extreme consequences.

2 Method

2.1 Participants

8 cardiovascular surgical teams were observed during their normal work hours at the Carilion Roanoke Memorial Hospital (CRMH). We chose to study cardiovascular teams because this study will be part of a future multi-site study with Massachusetts General Hospital (MGH) where we have another sample of cardiovascular surgical teams. The team members must be composed of at least one of each of the following: surgeon, anesthesiologist, circulating nurse, scrub technician and perfusionist (See figure 4 for participants' spatial disposition in the cardiovascular OR). The teams usually also include residents, students, and learners. They were observed as well when present. Currently there are 5 surgeons at the CRMH. A total of 85 participants were observed in the OR, however not everyone completed the questionnaires. The total number of participants who completed the questionnaire was 48. The total number of participants who completed the questionnaires was used for the model analysis whereas all participants present in the surgical room during the surgery were included for the social network analysis. Because the Cardiovascular Surgical department is relatively small, the same participants were present in multiple surgical procedure. Table 1 shows the participants present in each of the surgery. Because some of the surgical staff members did not complete the questionnaire, it is not possible to say how many unique participants were observed. However, of those who completed the questionnaire, there were 5 circulating nurses, 4 perfusionists, 5 scrub nurses, 2 surgical assistants, 7 anesthesiologists, 4 physician assistants and 5 surgeons.

Table 1

Participants Present in Each Surgery

Surgery	1	2	3	4	5	6	7	8
Surgeon	1	1	2	2	3	4	5	5
Circulator Nurse	1	1 n.q.	1	2	3 n.q.	4 n.q.	1 n.q. n.q.	5 n.q.
Anesthesiologist	n.q.	1	2 n.q.	3	4 n.q.	5	6 n.q.	7
Scrub Nurse	1 2 n.q.	1 2	1 n.q.	n.q. n.q.	n.q. n.q.	3 4 n.q.	1 3 n.q.	3 5 n.q.
Resident			n.q.					n.q.
Perfusionist	1	2	3	n.q.	4	1	4	4
Physician Assistant	n.q. n.q. n.q.	1	2 n.q.	3	n.q.	4	1 n.q.	1
Surgical Assistant	1		n.q.		1	n.q.		2 n.q.
Student			n.q.					n.q. n.q.
Total participants	11	8	12	7	12	10	12	13
Number of participants who filled out questionnaire	6	7	6	4	5	7	6	7

Table 1 shows the participant present in each surgery. Those who did not complete the questionnaire are designated as n.q. (no questionnaire). There was a total of five surgeons. Surgeon 1 completed surgeries 1 and 2, surgeon 2 completed surgery 3 and 4, surgeon 3 and 4 completed surgery 5 and 6 respectively, and surgeon 5 completed surgeries 7 and 8, however, this last surgeon did not complete the questionnaires. There was a total of five different circulating nurses. Circulating nurse 1 was present during four surgeries (surgery 1,2,3 and 7); circulating nurse 2 was present during one surgery (surgery 4). Circulating nurses 3,4 and 5 were present each during one surgery (surgery 5,6, and 8 respectively). Six circulating nurses did not complete the questionnaire. This, however, does not mean that there were six other different

circulating nurses (i.e. nurse 2 may have been one of the nurses that did not complete the questionnaire for surgery 5). This statement applies to all other professions as well. There was a total of seven anesthesiologists. Anesthesiologist 1,2,3,4,5,6, and 7 completed each one surgery (surgery 2,3,4,5,6, and 7 respectively). Four anesthesiologists did not complete the questionnaire. There was a total of five scrub nurses. Scrub nurse 1 and 2 worked together during two surgeries (surgery 1 and 2). Scrub nurse 1 was also present during surgery 3 and 7. Scrub nurse 3 was present during surgery 6 and 7. Scrub nurse 4 was present during one surgery, surgery 6 and scrub nurse 5 was present during surgery 8. Nine scrub nurses did not complete the questionnaire. Residents were present during surgery 3 and 8 but they did not complete the questionnaire. There are a total of four perfusionists. Perfusionists 1 was present during two surgeries (surgery 1 and 6); perfusionist 2 and 3 were present for one surgery each (surgery 2 and 3, respectively); perfusionist 4 was present during 3 surgeries (surgeries 5,7, and 8). One perfusionist did not complete the questionnaire. There was a total of four physician assistants (P.A.) who completed the questionnaires. P.A. 1 completed two surgeries (surgery 2 and 8); P.A. 2, 3, and 4 completed one surgery each (surgeries 3,4, and 5, respectively). Two surgical assistants (S.A.) were present. S.A. 1 was present during 2 surgeries (surgery 1 and 5); S.A. 2 was present during surgery 8. Three S.A.s did not complete the questionnaire. One student was present during surgery 1 and two students were present during surgery 8 but none of them completed the questionnaire.

Surgery 1 had a total of 11 surgical team members present. Of those 11 participants 6 completed the questionnaire (surgeon 1, circulator 1, scrub nurse 1, scrub nurse 2, perfusionist 1, and surgical assistant 1). Surgery 2 had a total of 8 surgical team members present. Of those 8 surgical team members, 7 members completed the questionnaire (surgeon 1, circulator 1,

anesthesiologist 1, scrub nurse 1, scrub nurse 2, perfusionist 2, and physician assistant 1). Surgery 3 had a total of 12 surgical team members. Of those 12 surgical team members, 6 completed the questionnaire (surgeon 2, circulator 1, anesthesiologist 2, scrub nurse 1, perfusionist 3 and physician assistant 2). Surgery 4 had a total of 7 surgical team members. Of those 7 surgical team members, 4 completed the questionnaire (surgeon 2, circulator nurse 2, anesthesiologist 3, and physician assistant 3). Surgery 5 had a total of 11 surgical team members. Of those 11 surgical team members, 5 completed the questionnaire (surgeon 3, circulator nurse 3, anesthesiologist 4, perfusionist 4 and surgical assistant 1). Surgery 6 had a total of 10 surgical team members. Of those 10 surgical team members, 7 completed the questionnaire (surgeon 4, circulator nurse 4, anesthesiologist 5, scrub nurse 3, scrub nurse 4, perfusionist 1, and physician assistant 4). Surgery 7 had a total of 12 surgical team members. Of those 12 surgical team members, 6 completed the questionnaire (circulator nurse 1, anesthesiologist 6, scrub nurse 1, scrub nurse 3, perfusionist 4, physician assistant 1). Surgery 8 had a total of 11 surgical team members. Of those 11 surgical team members, 7 completed the questionnaire (circulator nurse 5, anesthesiologist 7, scrub nurse 3, scrub nurse 5, perfusionist 7, physician assistant 1, surgical assistant 2).

2.2 Procedure

The participants were observed throughout the entirety of the surgical procedure (from the time-out to wound closure), verbal and non-verbal behaviors were coded to measure teamwork and leadership behaviors. The researcher asked the anesthesiologist for the American Society of Anesthesiologists (ASA) physical status score of the patient at the beginning of the operation and recorded the name of the procedure. During the post-closure phase, all surgical team members completed a brief questionnaire that evaluates psychological safety, perception of teamwork, buy-in to the time-out and trust. Each participant was assigned a unique code that was written on the questionnaire by the participant. The code consisted of the first two letters of the participants' parents' first name and participants' day of birth (e.g.: for an individual with parents Nicole and Paul, born on March 13th, the code would be nipa13). If participants do not know the first name of one of his/her parents, and to avoid any discomfort, they were instructed to write two "a" and "b". Thus, it is possible for the research team to link the questionnaires filled out by a same participant without identifying the participant. Questionnaires are designed as pen and paper short surveys (See Appendix C).

Because the tasks of the different professional groups are different and end at different times, OR staff usually leave the OR one-by-one. Senior surgeons usually leave the OR first, after completion of the most critical part of the surgery. They were the first to be asked to complete the questionnaire. Residents or fellows leave the OR after the wound closure and completed the questionnaires at that time, while scrubs and circulating nurses are responsible for the cleaning of the surgical devices. Finally, the anesthesiologist team is responsible for the emergence of the patient after the completion of the surgery and this is a phase of high workload for them, therefore the anesthesia team are the last participants to fill out the questionnaire. The

researcher did not interrupt any ongoing clinical task to gather data but waited until the team member had finished their work or left the OR. Please refer to Appendix A for a schematic representation of the methods.

2.3 Measures

2.3.1 Temporal Data Collection

Interactions among team members was coded live throughout the operation to create a one overall social network per team. An interaction is defined as any verbal or non-verbal communication or gesture that has a sender and a receiver to the behavior. Although interactions were coded throughout the procedures, the analysis was conducted with the data of five critical steps of the procedure (Table 2 and Figure 4).

Table 2

The Five Critical Steps During the Surgical Procedure

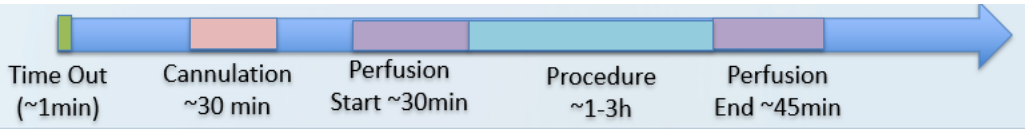
Critical step	Indicator of start of step	Indicator of end of step
Time-out	Surgeon says "let's time out"	Team moves on to do other things that are not part of the surgical safety checklist
Cannulation	Pericardium is open	Vessels are cannulated
Start of perfusion	Perfusionist gives cardioplegia	Perfusionist says "we are on pump"
Procedure	Perfusionist says "we are on pump"	Perfusionist says "adding volume"
End of perfusion	Perfusionist says "adding volume"	Perfusionist says "we are off pump"

Note. Table 2 shows the 5 critical moments of when each social network was coded, what behavior marks the beginning and end of each critical step. It is important to note that each surgery is different so terminology used by the surgical team may vary from team to team but these behaviors will be used as a guideline on when to start coding for each separate social network.

To measure these behaviors the number of interactions among team members and their duration was recorded on an iPad. This information yielded the social network. The number of interactions represents how many times each participant talked to other participants. The professional role of the participants that were interacting was also be recorded. The count of interactions and the professional roles associated with these interactions permitted us to create a social network.

Figure 4

Timeline of the Perioperative Process



Note. Depicted are the five critical steps used to create the five social networks and their approximate duration.

The operation starts with the *time out*, which is a moment when all the team gathers before incision when the patient is already under anesthesia. The surgical team performs the surgical safety checklist which addresses information regarding the medications, amount of blood, anesthesia, and potential problems the patient may have. The WHO Surgical Safety Checklist is provided in the Appendix B. The time out is very brief and usually lasts less than one minute. *Cannulation* represents the moment in which the surgeon is cannulating the heart vessels to put the heart on bypass. This process usually lasts about 30 minutes. The *start of perfusion* is when the perfusionist gives the patient cardioplegia which stops the heart so that the surgeon can operate on a non-beating heart. This enables the patient to receive oxygenated blood from an external machine. This process usually lasts about 30 minutes and requires extensive coordination between the surgeon, the perfusionist and the anesthesiologist. The *procedure* represents the time the surgeon and the resident or fellow operate on the heart. The time of this step depends on the procedure the patient is undergoing and can vary between 1-3 hours. Communication during this step is usually between the surgeon and the resident/fellow with occasional updates from the perfusionist. During the *end of perfusion*, the anesthesiologist and perfusionist give medication so that the heart may start beating again and the blood volume is then transferred back into the heart, the lungs start working again and the blood is oxygenated in a natural way. This step takes about 30-45 minutes. In this step there is extensive communication between the surgeon, anesthesiologist and perfusionist.

2.3.2 Trust

The Costa and Anderson (2011) scale of trust was used in this study. This scale was tested in two different samples: 98 hospital professionals and 395 social-care professionals. The scale is constructed in 4 subscales (propensity to trust; perceived trustworthiness; cooperative behaviors; monitoring behaviors) with a total of 21 items. Given the time limit for surgical team members to complete the questionnaire, only 2 of the subscales were used in the present study. Perceived trustworthiness was used because we are interested in understanding what the trust level is among the team. This subscale contains 6 items. Two questions ("in this team people will keep their word" and "some people in this team often try to get out of previous commitments") were taken out from the scale given that they are not pertinent to OR work. The subscale of monitoring behaviors was also used because it indicates if there is lack of trust among the team. This subscale contains 3 items. Refer appendix C for the specific questions utilized on the questionnaire.

2.3.3 Psychological Safety

Psychological safety was measured with the scale created by Edmondson et al (1999) (See Appendix C for full scale). This scale is part of the questionnaire that each team member receives at the end of each surgical procedure. One of the questions – "is it safe to take risks on this team"- as pointed out by several surgeons, is non-specific and up to interpretation. Taking a risk can be interpreted as a social risk (i.e. speaking up about something wrong that someone has done) or as a risk involving the patient or the task at hand (i.e. trying a new surgical method). Due to this ambiguity, the question was not included in the questionnaire.

2.3.4 Performance

Upon extensive observation, informal interviews with surgeons and the measures used by Parker and colleagues (2012), performance was measured by counting how many times the circulator nurse left the operating room to obtain instruments or to obtain information from someone outside the room. When the team initially gathers to perform the time out, they must talk about what devices they will need during the surgery. If planned appropriately, the circulating nurse does not leave the room, other than to take a break. Instead, if information is omitted during the time out and the circulating nurse needs to retrieve devices during the surgery, that role is left unfilled inside the operating room.

2.3.5 Past performance

Past performance was measured using the Edmonson (1999) scale which asks questions about the past performance of the team they worked with for that surgical case. Although we asked all surgical team members to fill out this section of the questionnaire, our interest is only with the response of the surgeon on perceived past performance of the team (Model 3). Refer to appendix C for the specific questions utilized on the questionnaire.

2.3.6 Teamwork and communication

The Co-Act scale (Kolbe, Burtscher, & Manser, 2013) was used to assess teamwork and communication (see Table 3). Every interaction during the perioperative process was coded in one of the following categories:

Explicit Action Coordination: instruction; speaking up; planning.

Implicit Action Coordination: monitoring; action-related taking to the room; provide assistance.

Explicit information coordination: information request; information evaluation; information on request; opinion request.

Implicit information coordination: gather information; information related talking to the room; information without request.

We added some additional interactions we thought were representative of frequent communications taking place to the Kolbe and colleagues' scale: opinion request, closed loop communication, counting and irrelevant communication.

Before the deployment of the current study, a surgeon was consulted to receive feedback on the questionnaire used during post-operation. The surgeon thought that it would be best to add "opinion request" in the explicit information coordination category of the scale. The rationale behind this is that surgical team members may ask other team members for their thoughts as a teaching or learning experience. The literature shows (Edmondson, 1999) that psychological safety is highly correlated with learning behaviors and therefore it was including in the scale given that it relates to the constructs we are measuring. We also added to the scale the category of closed loop communication, which is a unique type of communication that happens often between the surgeon, anesthesiologist and perfusionist. Counting of the instruments was added because it represents a standard process that each team must take part of. This is usually done between the scrub nurse and the circulating nurse towards the end of the surgery to make sure no instruments were left in the patient's chest cavity. When the scrub nurse and the circulating nurse are counting the instrument, their interactions are extremely fast and therefore we added this category because it was not feasible for the researcher to both live code the counting process and the interactions that were taking place around the surgical table. Irrelevant communication was

added to the scale to represent when the team is talking about something that is not relevant to the surgical case but rather about, for example, their personal life. These communications were added to the scale so that there would be no loss of information of the interactions taking place in the OR. The researcher was trained by an expert on coding verbal and non-verbal behaviors of videos of surgical procedures before gaining access to the OR. The researcher and the expert then coded together the verbal communications of 19 procedures for another research project. In the present study, there was only one coder, however, in future data collection, another student will be engaged in the observations to get a measure of reliability of the coding.

Table 3

Teamwork and Communication Categories

	Action Coordination	Information Coordination
Explicit	**Instruction** ("give me the fentanyl") **Speaking up** ("are you sure you want to intubate right now?") **Planning** ("when we finish intubation, we will call for an OR nurse")	**Information request** ("where is the defibrillator?") **Information evaluation** ("are you sure he has no allergies?") **Information on request** ("the defibrillator is in the OR next door") ***Opinion request** ("what do you think if we do x instead of y?")
Implicit	**Monitoring** (team member watches what another team member is doing) **Action related talking to the room** ("I am turning down the alarm") **Provide assistance** (after the physician announces he is going to intubate; the nurse holds out the laryngoscope)	**Gather information** (reading indicators on a monitor or patient's chart) **Information related talking to the room** ("he seems to feel better now") **Information without request** ("just to let you know, the patient might have a severe reaction to the anesthetic")
Other	**Closed loop communication** (surgeon says "bypass on" the perfusionist replies "bypass is now on" **Counting** (scrub nurse counts the needles and says "I have 24 needles" the circulator nurse replies "count of needles is correct") **Irrelevant** ("how was your weekend?")	

Note. Teamwork and communication among surgical team members has been separated in four distinct categories: explicit action coordination; implicit action coordination; explicit information coordination and implicit information coordination. Communication content is then separated in

more specific subcategories (i.e. instruction, speaking up, etc). Examples of communication for each subcategory has been provided.

2.3.7 Leadership

The Important Weighted Density (IWD) (Lemoine et al., 2020) of the social network calculated in five critical instances determined shared vs. autocratic leadership. The IWD measure builds upon the principles of density, decentralization, and eigenvector centralization because it weights the node's incoming ties, it takes into account the relative centrality compared to other nodes and the relative influence and centrality of neighboring nodes. The lower the IWD, the more autocratic the leadership and the higher the IWD, the more the leadership is shared.

2.3.8 Control Variables

Difficulty and length of procedure were used as control variables in the partial correlation of the model analysis. The difficulty of procedure was obtained through the questionnaire by asking each participant "how difficult was this procedure?" on a scale to 1 to 5 ranging from very easy to very difficult. The length of the procedure was obtained by the live coding. The researcher recorded the time in which the procedure started, which is when the surgeon made the first incision, and when the wound was closed. The time between the incision and wound closure represents the length of the procedure.

3 Analytic Approach

To obtain the aggregated variables of psychological safety and team's trust for model 1, the responses obtained from the questionnaire were first averaged per participant and then aggregated at the team level resulting in one score of psychological safety and one score of team's trust per team. The variable of teamwork/communication was obtained by the frequency of communication among the team. The variable for performance was obtained by counting how many times the circulator nurse left the OR. Model 1 was then analyzed using correlation to determine and test assumptions of interrelatedness and regression to determine the relationship to the performance outcome measure. The relationship between psychological safety and teamwork/communication, the relationship between teamwork/communication and team's trust, and the relationship between psychological safety and team's trust were correlated using a partial correlation controlling for difficulty of the procedure and the length of the procedure for each team. A regression was conducted with the variables of psychological safety, teamwork/communication and team's trust to predict performance for each team.

In model 2, the variable for the type of leadership used in each team was determined by the social network IWD measure. The responses from the questionnaire of psychological safety and team's trust were averaged per individual and then aggregated to the team level. Performance was obtained by counting the frequency by which the circulator nurse left the OR. Model 2 was then analyzed by using a partial correlation controlling for difficulty of the procedure and length of the procedure. The IWD measure for leadership of each team was correlated with psychological safety, team's trust and performance of each team.

In model 3, the variable for past performance of the team was obtained from the surgeon's questionnaire evaluating his perception of past performance of the team he/she had

just worked with. The trust the surgeon has in his/her team was also obtained thought the responses of the questionnaire. The type of leadership was obtained with the overall social network IWD measure. Model 3 was then analyzed using path analysis. The exogenous variable of past performance was modeled to have a direct effect on the trust the surgeon has in his/her team and this was subsequently modeled to have a direct effect on the type of leadership used by the surgeon.

4 Results

4.1 Descriptive Statistics

In the following section, the type of analysis and the descriptive statistics are reported for the measures of team's trust, psychological safety, performance, past performance, teamwork/communication, and type of leadership. Type of leadership was looked at through three lenses: with the entire surgical staff present in the social network analysis, with only the core team members present in the social network analysis, and through a temporal lens to see how the leadership dynamics change over time. The measures used in the models for the type of leadership were the ones obtained by the network analysis with all team members present across the five phases.

4.1.1 Interrater Agreement

Within team consensus was determined by using the interrater agreement ρ^2 which is derived from Generalizability Theory. Interrater agreement is defined as interrater agreement $\rho^2 = \sigma^2_{ITEM} / (\sigma^2_{ITEM} + \sigma^2_{RESPONDENT} + \sigma^2_{ERROR})$. Tables 4 and 5 provides the interrater agreement for each team in response to the questionnaire assessing team's trust and psychological safety, respectively. To obtain a higher interrater agreement for both trust and psychological safety the responses of four participants on the trust questionnaire and the responses of six participants on the psychological safety questionnaire were removed. These participants had an overall high rating for the constructs of trust and psychological safety, however when they answered the reverse phrased questions present on the questionnaire their answers reflected a low level of trust and psychological safety. This is an indication that they did not fully attend to the questions while completing the questionnaire and therefore we made the decision to drop those participants form the analysis if they gave two or more low ratings on the reverse phrased questions.

Table 4

Interrater Agreement for Trust

Team	ρ^2 Interrater agreement
1 (surgeon 1)	0.77
2 (surgeon 1)	0.60
3 (surgeon 2)	0.27
4 (surgeon 2)	0.69
5 (surgeon 3)	0.55
6 (surgeon 4)	0.62
7 (surgeon 5)	0.54
8 (surgeon 5)	0.59

Table 5

Interrater Agreement for Psychological Safety

Team	ρ^2 Interrater agreement
1 (surgeon 1)	0.41
2 (surgeon 1)	0.40
3 (surgeon 2)	0.38
4 (surgeon 2)	0.47
5 (surgeon 3)	0.73
6 (surgeon 4)	0.37
7 (surgeon 5)	0.48
8 (surgeon 5)	0.21

4.1.2 Correlations

A correlation matrix (table 6) is provided with all the measures used in the analysis. The matrix shows some high correlations for teams 2 and 3 for the measures of team's trust and psychological safety. A possible reason for these high correlations is the overlap in participants in the two teams. For example, the same scrub nurse and the same circulating nurse were present for both surgery 2 and 3. For within team correlations please refer to appendix I.

Table 6

Correlation Matrix of leadership, Psychological Safety, Team's Trust, Past Performance, Teamwork and Communication and Performance

Correlation Matrix

			Leaderhsip	Psychological Safety								Team's Trust								Surgeon's Perception of Past Performace						Teamwork/Communication	Performance
			IWD	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	surgeon 1 (Team 1)	surgeon 1 (Team 2)	surgeon 2 (Team 3)	surgeon 2 (Team 4)	surgeon 3 (Team 5)	surgeon 4 (Team 5)	communication frequency	Performance
Leadership	IWD	Pearson Correlation	1																								
		Sig. (2-tailed)																									
		N	8																								
Psychological Safety	Team 1	Pearson Correlation	0.363	1																							
		Sig. (2-tailed)	0.479																								
		N	6	6																							
	Team 2	Pearson Correlation	-0.487	-0.435	1																						
		Sig. (2-tailed)	0.268	0.389																							
		N	7	6	7																						
	Team 3	Pearson Correlation	0.604	-0.334	-0.510	1																					
		Sig. (2-tailed)	0.204	0.517	0.301																						
		N	6	6	6	6																					
	Team 4	Pearson Correlation	-0.781	-0.226	.895*	-0.824	1																				
		Sig. (2-tailed)	0.119	0.715	0.040	0.086																					
		N	5	5	5	5	5																				
	Team 5	Pearson Correlation	-0.622	-0.272	0.667	-0.299	0.748	1																			
		Sig. (2-tailed)	0.263	0.658	0.219	0.625	0.146																				
		N	5	5	5	5	5	5																			
	Team 6	Pearson Correlation	-0.652	0.443	0.061	-.912*	0.630	0.167	1																		
		Sig. (2-tailed)	0.113	0.378	0.896	0.011	0.255	0.789																			
		N	7	6	7	6	5	5	7																		
	Team 7	Pearson Correlation	-0.010	-0.151	-0.430	0.059	-0.343	-0.707	0.137	1																	
		Sig. (2-tailed)	0.986	0.775	0.395	0.912	0.572	0.182	0.796																		
		N	6	6	6	6	5	5	6	6																	
	Team 8	Pearson Correlation	0.236	-0.317	0.060	0.570	-0.323	0.210	-0.648	-0.526	1																
		Sig. (2-tailed)	0.610	0.540	0.898	0.237	0.596	0.734	0.115	0.284																	
		N	7	6	7	6	5	5	7	6	7																

Correlation Matrix

			Leaderhsip	Psychological Safety								Team's Trust								Surgeon's Perception of Past Performace						Teamwork/Communication	Performance
			IWD	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	surgeon 1 (Team 1)	surgeon 1 (Team 2)	surgeon 2 (Team 3)	surgeon 2 (Team 4)	surgeon 3 (Team 5)	surgeon 4 (Team 5)	communication frequency	Performance
Team's Trust	Team 1	Pearson Correlation	0.285	.916*	-0.101	-0.417	0.088	0.087	0.386	-0.482	-0.231	1																
		Sig. (2-tailed)	0.584	0.010	0.849	0.411	0.888	0.890	0.450	0.333	0.660																	
		N	6	6	6	6	5	5	6	6	6	6																
	Team 2	Pearson Correlation	-0.657	-0.178	.818*	-.848*	.897*	0.433	0.468	-0.108	-0.142	-0.016	1															
		Sig. (2-tailed)	0.109	0.736	0.025	0.033	0.039	0.467	0.290	0.839	0.761	0.976																
		N	7	6	7	6	5	5	7	6	7	6	7															
	Team 3	Pearson Correlation	0.465	-0.533	-0.006	.840*	-0.423	0.118	-.966**	-0.218	0.513	-0.405	-0.562	1														
		Sig. (2-tailed)	0.353	0.276	0.991	0.036	0.478	0.850	0.002	0.678	0.298	0.425	0.246															
		N	6	6	6	6	5	5	6	6	6	6	6	6														
	Team 4	Pearson Correlation	0.425	0.434	0.042	0.231	0.000	0.438	-0.403	-.879*	0.376	0.690	-0.358	0.526	1													
		Sig. (2-tailed)	0.476	0.465	0.947	0.709	1.000	0.460	0.501	0.050	0.532	0.197	0.554	0.362														
		N	5	5	5	5	5	5	5	5	5	5	5	5	5													
	Team 5	Pearson Correlation	-0.314	-0.068	0.797	-0.395	0.748	0.847	0.071	-0.877	0.161	0.373	0.491	0.165	0.620	1												
		Sig. (2-tailed)	0.607	0.913	0.106	0.511	0.146	0.070	0.910	0.051	0.795	0.536	0.401	0.791	0.264													
		N	5	5	5	5	5	5	5	5	5	5	5	5	5	5												
	Team 6	Pearson Correlation	-0.483	0.550	0.144	-0.697	0.779	0.789	.757*	-0.526	-0.115	0.650	0.373	-0.696	0.485	0.791	1											
		Sig. (2-tailed)	0.272	0.259	0.758	0.124	0.120	0.113	0.049	0.284	0.806	0.162	0.410	0.125	0.407	0.111												
		N	7	6	7	6	5	5	7	6	7	6	7	6	5	5	7											
	Team 7	Pearson Correlation	-0.345	-0.176	-0.482	0.073	-0.314	-0.349	0.272	0.731	-0.084	-0.512	-0.073	-0.342	-0.772	-0.775	-0.116	1										
		Sig. (2-tailed)	0.503	0.739	0.333	0.890	0.607	0.565	0.602	0.099	0.874	0.299	0.891	0.507	0.126	0.124	0.827											
		N	6	6	6	6	5	5	6	6	6	6	6	6	5	5	6	6										
	Team 8	Pearson Correlation	0.123	-0.174	0.337	-0.067	-0.042	-0.108	-0.307	-0.291	0.689	-0.118	0.415	-0.075	-0.112	0.128	-0.011	-0.080	1									
		Sig. (2-tailed)	0.792	0.742	0.459	0.900	0.947	0.862	0.504	0.576	0.087	0.824	0.355	0.888	0.857	0.837	0.981	0.881										
		N	7	6	7	6	5	5	7	6	7	6	7	6	5	5	7	6	7									

Correlation Matrix

			Leaderhsip	Psychological Safety								Team's Trust								Surgeon's Perception of Past Performace						Teamwork/Communication	Performance
			IWD	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	surgeon 1 (Team 1)	surgeon 1 (Team 2)	surgeon 2 (Team 3)	surgeon 2 (Team 4)	surgeon 3 (Team 5)	surgeon 4 (Team 5)	communication frequency	Performance
Surgeon's Perception of Past Performance	surgeon 1 (Team 1)	Pearson Correlation	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1							
		Sig. (2-tailed)																									
		N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4							
	surgeon 1 (Team 2)	Pearson Correlation	0.696	.961*	-0.695	0.137	-0.420	-0.242	0.085	0.016	-0.322	0.827	-0.651	-0.151	0.471	-0.228	0.195	-0.098	-0.889	.	1						
		Sig. (2-tailed)	0.304	0.039	0.305	0.863	0.580	0.758	0.915	0.984	0.678	0.173	0.349	0.849	0.529	0.772	0.805	0.902	0.111								
		N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4						
	surgeon 2 (Team 3)	Pearson Correlation	-0.412	-0.149	0.116	-0.546	0.173	-0.500	0.631	0.831	-0.666	-0.376	0.532	-0.757	-0.943	-0.457	-0.273	0.683	0.081	.	-0.333	1					
		Sig. (2-tailed)	0.588	0.851	0.884	0.454	0.827	0.500	0.369	0.169	0.334	0.624	0.468	0.243	0.057	0.543	0.727	0.317	0.919		0.667						
		N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4					
	surgeon 2 (Team 4)	Pearson Correlation	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1				
		Sig. (2-tailed)																									
		N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4				
	surgeon 3 (Team 5)	Pearson Correlation	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1			
		Sig. (2-tailed)																									
		N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4			
	surgeon 4 (Team 6)	Pearson Correlation	0.696	.961*	-0.695	0.137	-0.420	-0.242	0.085	0.016	-0.322	0.827	-0.651	-0.151	0.471	-0.228	0.195	-0.098	-0.889	.	1.000**	-0.333	.	.	1		
		Sig. (2-tailed)	0.304	0.039	0.305	0.863	0.580	0.758	0.915	0.984	0.678	0.173	0.349	0.849	0.529	0.772	0.805	0.902	0.111		0.000	0.667					
		N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		
Teamwork/ Commu	communication frequency	Pearson Correlation	-0.494	0.521	-0.101	-0.525	0.689	0.874	0.703	-0.430	-0.080	0.532	0.134	-0.670	0.669	0.878	.896**	0.050	-0.064	.	0.166	-0.520	.	.	0.166	1	
		Sig. (2-tailed)	0.213	0.290	0.829	0.285	0.198	0.053	0.078	0.394	0.864	0.277	0.774	0.145	0.217	0.050	0.006	0.925	0.891		0.834	0.480			0.834		
		N	8	6	7	6	5	5	7	6	7	6	7	6	5	5	7	6	7	4	4	4	4	4	4	8	
Performa	Performance	Pearson Correlation	-0.200	0.550	-.770*	-0.015	-0.522	-0.449	0.336	0.472	-0.194	0.211	-0.334	-0.514	-0.271	-0.741	0.174	0.696	-0.216	.	0.801	0.160	.	.	0.801	0.638	1
		Sig. (2-tailed)	0.635	0.259	0.043	0.977	0.367	0.448	0.461	0.345	0.677	0.688	0.464	0.297	0.659	0.152	0.709	0.125	0.642		0.199	0.840			0.199	0.089	
		N	8	6	7	6	5	5	7	6	7	6	7	6	5	5	7	6	7	4	4	4	4	4	4	8	8

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

Note. Some measures were not computed in the correlation matrix because the responses for that construct were all the same. For example, for the surgeon's perception of past performance measure for surgeon 2, there are no correlations because he/she responded to all questions of the questionnaire with the same number on the Likert scale and therefore there was no variability in the response.

4.1.3 Trust

Trust was measured with a 7-point Likert scale. The measures of the 7 items on the scale were averaged per individual to obtain one score of trust per team member. The descriptive statistics are reported in Table 7.

Table 7

Descriptive Statistics of Trust Among Team Members

Team	n	minimum	maximum	mean	St. dev
1 (surgeon 1)	6	3.00	4.43	3.76	0.61
2 (surgeon 1)	7	3.29	5.43	4.35	0.86
3 (surgeon 2)	6	3.43	4.86	4.14	0.51
4 (surgeon 2)	5	4.29	4.71	4.00	0.19
5 (surgeon 3)	5	2.14	4.86	3.88	1.11
6 (surgeon 4)	7	3.00	5.43	4.14	0.79
7 (surgeon 5)	6	3.14	4.71	3.90	0.58
8 (surgeon 5)	7	3.14	4.14	3.67	0.37

4.1.4 Psychological Safety

Psychological Safety was measured with a 7-point Likert scale. The measures of the 6 items on the scale were averaged per individual to obtain one score of psychological safety per team member. The descriptive statistics are reported in Table 8.

Table 8

Descriptive Statistics for Psychological Safety

Team	N	minimum	maximum	mean	St. dev
1 (surgeon 1)	6	2.83	6.00	4.77	1.22
2 (surgeon 1)	7	2.33	6.83	4.52	1.41
3 (surgeon 2)	6	3.00	6.50	4.94	1.41
4 (surgeon 2)	5	3.83	6.33	5.33	0.98
5 (surgeon 3)	5	2.67	6.50	5.43	1.57
6 (surgeon 4)	7	3.00	7.00	5.38	1.63
7 (surgeon 5)	6	2.50	6.83	4.78	1.49
8 (surgeon 5)	7	3.00	6.00	4.64	1.04

4.1.5 Performance

Performance was measured by counting how many times the circulator nurse left the operating room to retrieve instruments that were then utilized in the surgery. The times the circulator nurse left for a break were not utilized in this analysis. Table 9 shows the number of times, for each surgery, that the circulator nurse left the operating room and the times she/he left per hour.

Table 9

Performance measure for each team

Team	Performance Score	Times circulator nurse left per hour
1 (surgeon 1)	6	1.99
2 (surgeon 1)	4	1.35
3 (surgeon 2)	1	0.35
4 (surgeon 2)	3	0.55
5 (surgeon 3)	6	1.96
6 (surgeon 4)	6	1.68
7 (surgeon 5)	4	0.93
8 (surgeon 5)	10	2.24

4.1.6 Past Performance

Past performance was measured using a 7-pont Likert Scale. Perceived past performance of the team was measured with 4 items on the questionnaire. Although all team members received the same questionnaire, the surgeon's response is the only one we are focused on for this analysis. Table 10 provides each measure of perceived past performance for each surgeon's team. One of the surgeons did not complete the questionnaires for two procedures and therefore there are a total of 6 surgeon's measures.

Table 10

Surgeon's Perceived Past Performance of His/Her Team

Team and Surgeon	Past Performance average	Minimum	Maximum	St. Dev
1 (surgeon 1)	6	6	6	0
2 (surgeon 1)	5	2	5	2
3 (surgeon 2)	5.7	5	6	.5
4 (surgeon 2)	6	6	6	0
5 (surgeon 3)	7	7	7	0
6 (surgeon 4)	4.7	4	5	.5

4.1.7 Teamwork and Communication

Teamwork and Communication was measured with the use of the Co-Act Scale. Each interaction from each team member was live coded with a specific category according to the content of the interaction. Table 11 provides the summary of all the interactions of all the teams. Individual level interactions (who is talking to whom and what they are saying) is available upon request.

Table 11

All Interactions Taking Place During Each Surgery

team	1	2	3	4	5	6	7	8	total
Surgeon	1	1	2	2	3	4	5	5	
n participants	11	8	12	7	12	10	12	13	85
n interactions	259	322	291	322	302	524	507	653	3180
length of surgery (min)	181	177	171	147	183	214	259	268	1600
instructions	59	136	83	86	87	207	134	186	978
speaking up	3	0	0	0	0	0	0	1	4
planning	4	1	2	2	4	7	2	6	28
monitoring	4	0	0	1	1	0	1	1	8
action related talking to the room	5	2	5	3	1	1	1	3	21
providing assistance	26	30	53	46	50	77	73	92	447
information request	29	27	20	25	27	51	34	58	271
information evaluation	4	6	1	1	3	2	11	8	36
information on request	30	28	22	30	27	57	40	67	301
gather information	4	0	0	0	0	0	0	0	4
information related talking to the room	18	3	4	6	4	4	3	2	44
Information without request	3	17	12	24	19	21	38	21	155
X (do not know what they said)	45	30	48	30	44	36	54	68	355
teaching	7	0	15	0	6	7	14	18	67
closed loop communication	13	42	24	54	29	21	69	101	353
counting	4	1	2	1	1	1	1	1	12
irrelevant to case	0	0	0	13	3	31	27	20	94
opinion request	0	0	0	0	1	1	3	0	5

Note. Table 11 shows all the interactions that took place throughout the surgery for each team. The second row represents the number of surgical staff members present during the surgery. The third row shows the total number of interactions that took place during that surgery. The fourth row shows the length in minutes of the surgery. The following rows show the frequency of the type of interactions. For example, team 1 had 59 interactions that were instructions.

4.2 Social Network Analysis

Type of Leadership was analyzed using social network analysis. The measure of Importance Weighted Density (IWD) was used to determine the type of leadership used in each surgery. The IWD measure can range from 0 to 1. Using social network analysis to determine sharedness of leadership has been published in multiple studies (e.g. Carson, Tesluk, Marrone, 2007; Chiu, Owens, Tesluk 2016; Mathieu, Kukenberger, D'Innocenzo, Reilly, 2015). To determine the impact of sharedness on performance these previous studies used the density measures from the social network analysis. There are no formal cutoffs of when a team should be considered as having a shared versus an autocratic leadership approach. Therefore, the data is presented as rankings of which team had the highest and lowest IWD relative to this sample. As mentioned previously, the type of leadership was analyzed through three lenses: overall social network analysis, which looks at all the interactions from all team members; small group social network analysis, which examines the interaction of the core team, omitting all other team members; and the temporal social network analysis, which explored the interactions broken down by phases of the surgical procedure. In the model analysis the overall social network analysis was used.

4.2.1 Overall Social Network Analysis

Each team's interactions were inserted into a social network and the IWD measure was obtained. Table 12 shows the IWD measures for the overall social network analysis that included all five phases of the surgery.

Table 12

Importance Weighted Density of the Overall Social Network Analysis for Each Team

Team	IWD
1 (surgeon 1)	0.1430
2 (surgeon 1)	0.0927
3 (surgeon 2)	0.0806
4 (surgeon 2)	0.1299
5 (surgeon 3)	0.0659
6 (surgeon 4)	0.0849
7 (surgeon 5)	0.0792
8 (surgeon 5)	0.0711

To facilitate the comparison between teams, a table with the overall IWD, centrality and density measures was provided (Table 13). The definitions of each of these measures are provided in the Appendix D.

Table 13

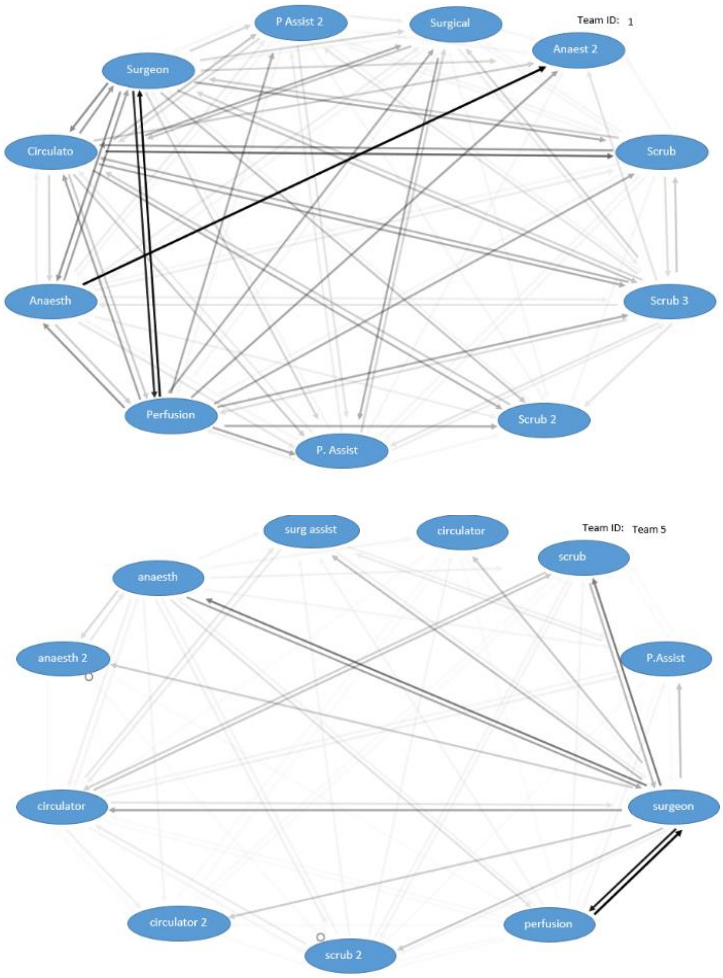
Social Network Measures for Each Team

Measure	Team 1 (surgeon 1)	Team 2 (surgeon 1)	Team 3 (surgeon 2)	Team 4 (surgeon 2)	Team 5 (surgeon 3)	Team 6 (surgeon 4)	Team 7 (surgeon 5)	Team 8 (surgeon 5)
Importance Weighted Density	0.1430	0.0927	0.0806	0.1299	0.0659	0.0849	0.0792	0.0711
Density mean	0.836	0.875	0.439	0.857	0.576	0.778	0.5	0.545
Betweenness Centrality Mean	0.045	0.112	0.111	0.167	0.070	0.117	0.105	0.094
Betweenness Centrality St. Dev	0.041	0.072	0.133	0.198	0.073	0.076	0.087	0.095
Closeness Centrality Mean	0.372	0.369	0.275	0.357	0.389	0.351	0.348	0.379
Closeness Centrality St.Dev.	0.268	0.163	0.161	0.137	0.206	0.112	0.127	0.201
Centrality Eigenvector Mean	0.400	0.408	0.339	0.467	0.333	0.371	0.309	0.294
Centrality Eigenvector St. Dev	0.146	0.289	0.228	0.261	0.236	0.249	0.267	0.259
Centrality Total Degree Mean	0.151	0.106	0.113	0.142	0.061	0.095	0.076	0.060
Centrality Total Degree St. Dev	0.075	0.080	0.081	0.106	0.065	0.071	0.082	0.068

To illustrate the difference in the social networks, the highest (team 1) and lowest (team 5) importance weighted density networks are presented below. To view all networks along with their descriptive statistics, please refer to Appendix E.

Figure 5

Overall Social Network for Team 1 (surgeon 1) and Team 5 (surgeon 3)



Note. The figure shows the network of Team 1(above) and Team 5 (below). Each surgical staff member is represented by a blue oval containing their role. When a team member interacted with another team member, a link was created between the two. The more they interact, the darker the link. Team 1 has 11 members; the density is 0.836 and the IWD is 0.143. Team 5 has 11 members, a density of 0.575 and the IWD is 0.066.

The analysis for the type of leadership shows that there are distinctions in terms of how much each team communicates. For example, the comparison between team 1 and team 5 (Figure 5) shows that in team 1 everyone is interacting with each other to some degree and the

leadership is more shared. Whereas in team 5, the interactions are less frequent among team members, the leadership is more autocratic residing mostly with the surgeon who has the majority of links coming and going from him/her. This is both reflected in the social network figure and in the IWD measure (Figure 5 and Table 12). In both teams, the predominant interactions are between the surgeon and the perfusionist. This is no surprise because going on and off perfusion is a complicated process that needs extensive communication so that both the surgeon and the perfusionist are on the same page as the surgery evolves. The surgeon operates on the heart but the perfusionist is responsible of how much volume of blood is going through the heart, which facilitates the surgeon's surgical work. The surgeon and the perfusionist also communicate extensively with the anesthesiologist throughout the surgery to make sure that the patient is under the appropriate amount of anesthesia. These interactions are very much task driven, which may be indicative that the communication in the operating room is task focused rather than team focused during certain phases.

4.2.2 Core Team Social Network Analysis

To further the exploratory analysis, the core team's interactions were taken for comparison through social network analysis. The core team consists of the surgeon, perfusionist, anesthesiologist, circulator nurse and scrub nurse. The following table shows the main statistics for each of the teams.

Table 14

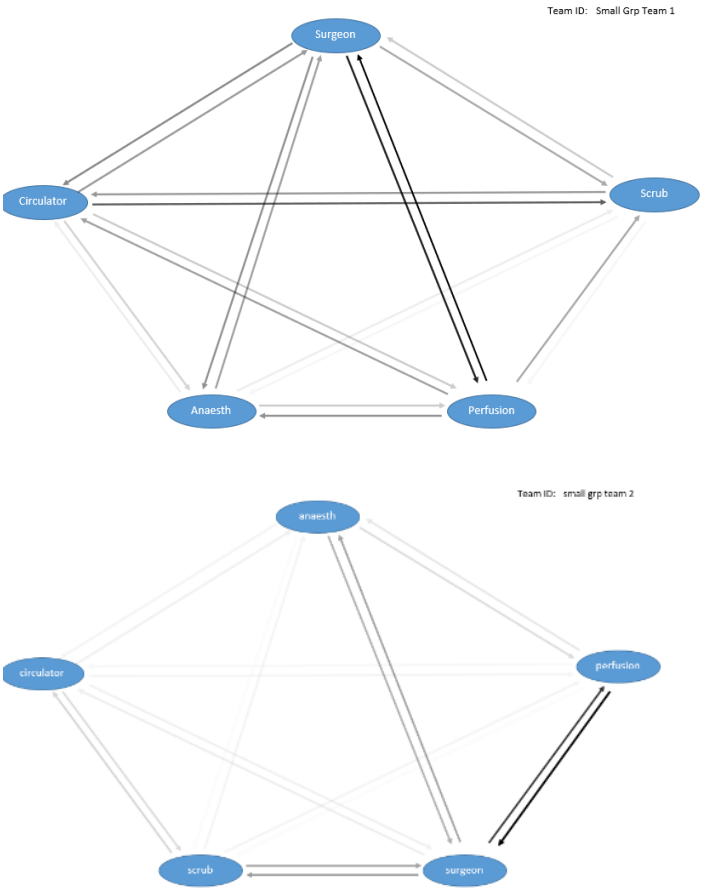
Importance Weighted Density and Decentralization for Each Core Team

Team	IWD	Density	Decentralization
1 (surgeon 1)	0.308	0.35	0.822
2 (surgeon 1)	0.177	0.208	0.721
3 (surgeon 2)	0.205	0.218	0.815
4 (surgeon 2)	0.211	0.234	0.770
5 (surgeon 3)	0.209	0.237	0.759
6 (surgeon 4)	0.187	0.220	0.687
7 (surgeon 5)	0.229	0.268	0.657
8 (surgeon 5)	0.227	0.278	0.655

As an illustrative example, the following two figures show the core team with the highest (team 1) and lowest (team 2) IWDs. Refer to appendix F to see all core team social networks.

Figure 6

Core Team Social Network for Team 1 (surgeon 1) and Team 2 (surgeon 1)



Note. Figure 6 shows the network of Team 1 (above) and Team 2 (below). Each surgical staff member is represented by a blue oval containing their role. When a team member interacted with another team member, a link was created between the two. The more they interact, the darker the link. Team 1 has 5 members; the density is 0.35 and the IWD is 0.308. Team 5 has 5 members, a density of 0.237 and the IWD is 0.209.

A core group social network analysis was created for each team (Table 14, Figure 6). The core group is represented by the surgeon, anesthesiologist, perfusionist, circulating nurse and scrub nurse. These team members always must be present during the surgery. The social network constructed with the core groups show the triangular shape of the interaction between the

surgeon, anesthesiologist and perfusionist (see figure 6). The scrub nurse and the circulator nurse are also included in the core group because their roles are functionally indispensable. The circulator nurse has an overview of what is happening inside the operating room and helps all team member when they need assistance.

4.2.3 Temporal Social Network Analysis

We examined how the social networks change with time throughout the surgery. This analysis was done to show that throughout the surgery, leadership is needed from different team members at different times because of the need for relevant skills that each team member can contribute as the situation evolves. The following table shows the IWD measure for each team across all five phases of the surgery.

Table 15

Leadership Measure of All Teams Across the Five Phases of Surgery

Teams	IWD Time Out	IWD Cannulation	IWD Start of Perfusion	IWD Procedure	IWD End of Perfusion
Team 1 (surgeon 1)	0.49	0.12	0.04	0.06	0.13
Team 2 (surgeon 1)	0.32	0.3	0.05	0.13	0.07
Team 3 (surgeon 2)	0.21	0.22	0.04	0.12	0.16
Team 4 (surgeon 2)	0.24	0.25	0.04	0.23	0.08
Team 5 (surgeon 3)	0.66	0.08	0.10	0.12	0.07
Team 6 (surgeon 4)	0.18	0.13	0.10	0.06	0.06
Team 7 (surgeon 5)	0.21	0.32	0.11	0.05	0.10
Team 8 (surgeon 5)	0.17	0.22	0.10	0.05	0.05

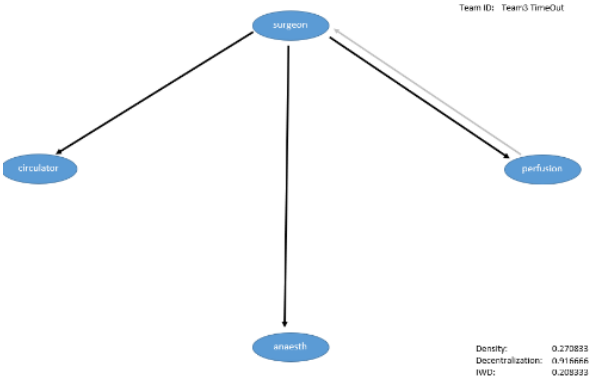
The following figures show the social network created during the time out, cannulation, start of perfusion, the procedure and when the patient is taken off bypass (perfusion end). As an illustrative example, the entirety of the surgery where team 3 participates in is shown. To see all teams, refer to appendix G.

Figure 7

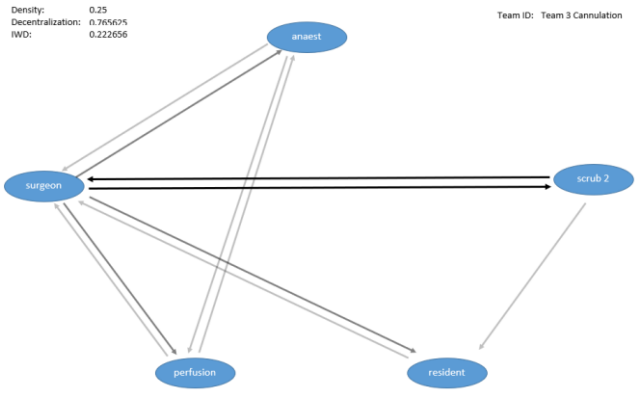
Temporal Social Network for Team 3 (surgeon 2)

Team 3

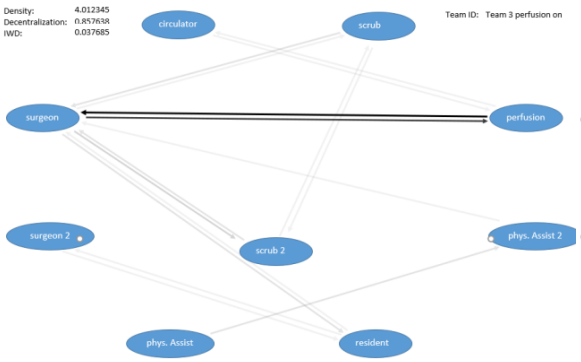
1. Timeout



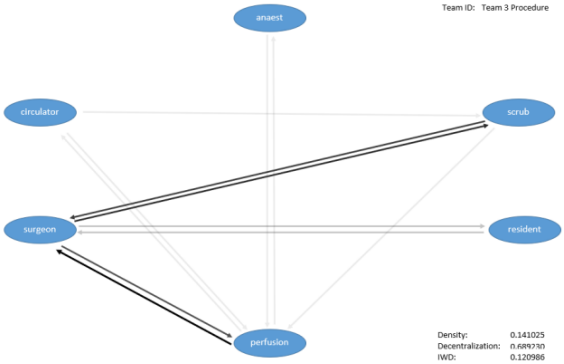
2. Cannulation



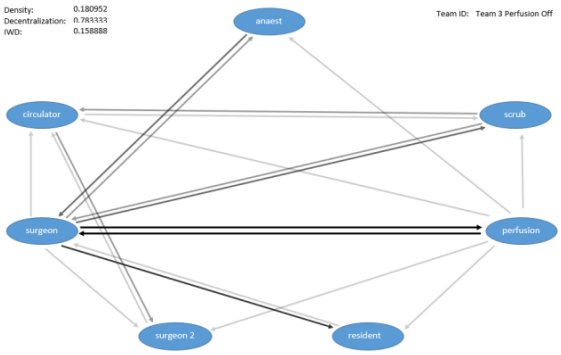
3. Start of perfusion



4. Procedure



5. End of perfusion:



Note. Figure 7 shows the five different stages of the surgery – time out, cannulation, start of bypass, procedure, and end of procedure – with the team members who interacted during those stages.

During the five stages explored in this study, the leadership flows to those who have the skill to interact and help the team achieve their collective goal. Team 3 was chosen as an illustrative example: during the first phase of the surgery, the time out, all interactions were either from the surgeon or to the surgeon. During cannulation and the procedure, the scrub nurse and the surgeon have the most interaction because the surgeon is doing work on the heart and the scrub nurse provides the instruments and helps the surgeon as needed. The perfusionist and the anesthesiologist are present and communicate with the surgeon, however, their roles emerge during the start and end of the perfusion, which is when the heart must stop and start beating again, respectively. That triangulation of interaction between the surgeon, anesthesiologist and perfusionist is needed so that all three are situationally aware of what is happening with the patient and synchronized in terms of the medicine and blood volume to give to the patient. This is well represented in Table 14 which shows the IWD for each team across all five of the surgical phases. The IWD measure is lower during the start and end of perfusion which are moments in which only the surgeon, perfusionist and anesthesiologist have the technical skills to accomplish that task and it does not require coordination with other members, whereas the time out is a moment designed for all team members to participate and voice their concerns for the patient and therefore the IWD is higher resulting in sharedness of the leadership.

4.2.4 Summary of Social Network Analysis

The goal of this exploratory study was to understand where and when certain leadership behaviors take place and what effect it may have on psycho-social states of the team. Leadership

is a pattern of emerging influences within the team and communication is the medium through which these influences take form. The Co-Act framework allowed us to gain insight on which type of communication each team member was contributing throughout the surgical procedure. We were interested in understanding which communications take place the most during surgery and the results show that most of the interactions are instructions and providing assistance (Table 11). This shows that the communication during a surgery is both directive, such as giving instructions to team members, but also collaborative such as when team members provide assistance to each other.

The social network findings show that most interactions during the surgery are inherently task driven. The complexity of the task determines the amount of coordination between the surgical team members. For example, when the team goes on and off perfusion there is the need of coordination between the surgeon, perfusionist and anesthesiologist who have the technical skills to perform that task. The fact that only those three parties are involved in that phase results in a more autocratic leadership approach when comparing the interactions of the entire team in that phase (see Figure 7). These patterns of communication seem to indicate that an autocratic leadership approach is taken when the situation at hand demands coordination for a task, whereas a more shared type of leadership approach is taken when there is need for information sharing, such as during the time out. The major contribution of this exploratory study is the analysis of these patterns of communication by phases. The overall IWD measure for the entire surgery may not be an accurate representation of the leadership of the team. The low scores for the IWD during the start and end of perfusion may be impacting the overall measure of leadership of the team because of the high dependance of communication on the tasks in those specific phases. Because this is such a task driven environment, we used the surgical tasks to define the phases of

communication as a medium to measure leadership within each of the phases and see these patterns emerge. We were able to understand who the main actors are and how much are they contributing to the dynamics of the team throughout time. The findings of this exploratory analysis overall show that surgical team members use distinct leadership styles depending on the task at hand. We can therefore tell in which of the phases is an autocratic or shared leadership approach taken.

Klein (2006) showed that dynamic delegation can enhance the team's ability to perform well in trauma teams. Dynamic delegation can be useful when team members have unique skills to perform the task and especially when there is a junior leader that needs to be trained to perform those tasks. Shared leadership enables dynamic delegation by transferring the leadership role up and down the hierarchy. Given that a shared leadership approach has been shown to enhance performance, further studies should correlate these leadership patterns by phases to a specific performance outcome so that we can understand which type of leadership is more optimal in which phase. Furthermore, researchers should also address how unexpected events may change the dynamics of the team and if there is an increase or decrease of coordination between team members – will the leader take the time to share information with the entire team or will they try to deal with the situation on their own - and to what extent is either approach more beneficial to the patient's safety.

4.3 Model Analysis

4.3.1 Assumption Analysis

Assumption to analyze the correlation of the constructs were checked. Normality was checked with the measures of skewness, kurtosis, the Shapiro-Wilks test of significance and a normal Q-Q plot. Outliers were determined using a box plot. Linearity and homoscedasticity

were determined using a scatter plot and the residuals vs predicted plots, respectively. The assumptions of normality were all met except for the surgeon's trust in the team which had a kurtosis value of 2.053. Kurtosis should be between -2 and 2 (Hair, Black, Babin, & Anderson, 2010). There was only one outlier for the performance measure (team 8). None of the scatterplots showed a polynomial type of linearity, therefore the assumption for linearity was met. The plots of the residuals vs predicted showed some heteroscedasticity for the relationship between leadership and psychological safety and for psychological safety and team's trust. All teams were included in the analysis due to the small sample size. For all plots and measures of the assumption analysis, please refer to appendix H.

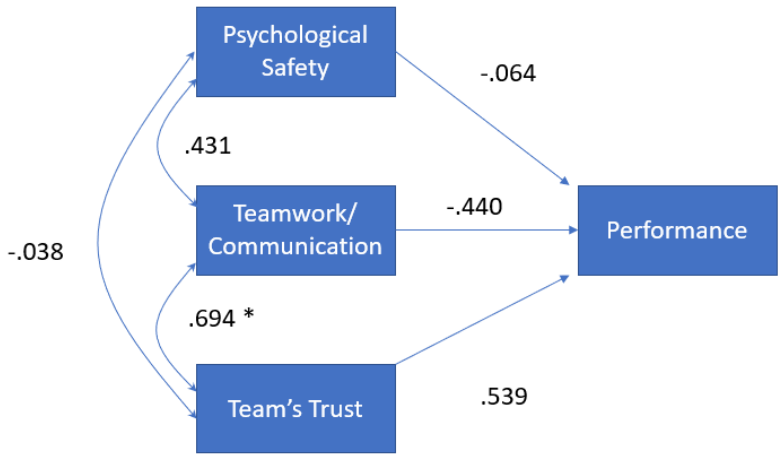
An alpha level of .1 was used for all statistical tests to account for the analysis being underpowered.

4.3.2 Model 1

The analysis for model 1 was conducted through partial correlation controlling for the difficulty of the procedure and the length of the surgery. Psychological safety was correlated with teamwork/communication and team's trust. Team's trust was correlated with teamwork/communication. Regression was used to determine the unique contribution of psychological safety, teamwork/communication, and team's trust on performance (Figure 8).

Figure 8

Diagram of Model 1 with the Corresponding Correlation and Regression Coefficients



1 a. Psychological Safety and Team's Trust

Team level scores for both psychological safety and team's trust were correlated. Results show that there is a non-significant negative correlation between psychological safety and team's trust r=-.038, p=.246.

1 b. Psychological Safety and Teamwork/Communication

The total number of interactions was correlated to the aggregate scores of psychological safety. Results show that there is a non-significant positive correlation between psychological safety and frequency of communication r=.431, p=.385

Further analysis was conducted to understand if there is a relationship with the type of communication used (directive vs. relational) and the levels of psychological safety at the group level. The following interactions were classified as directive: instructions, monitoring, information request and information on request. The following interactions were classified as relational: speaking up, planning, action related talking to the room, providing assistance, information evaluation, gathering information, information related talking to the room, information without request. All other interactions (teaching, closed loop communication, counting and irrelevant communication to the case) were excluded. The results show that there is

a non-significant positive correlation between psychological safety and relational communication r=.382, p=.175, whereas there is a non-significant negative correlation between psychological safety and directive communication r=-.220, p=.305.

1 c. Team's Trust and Communication

The total number of interactions was correlated with the aggregate score of team's trust for each team. The results show that there is a significant positive correlation between team's trust and frequency of communication r= .694, p=.053.

Further analysis was conducted to understand if there is a relationship with the type of communication used (directive vs. relational) and the levels of team's trust at the group level. The results show that there is a non-significant positive correlation between team's trust and relational communication r=.239, p=.284, whereas there is a non-significant negative correlation between team's trust and directive communication r=-.263, p=.265.

1 d. Psychological safety, Communication and Team's Trust predicting Performance

A multiple regression was conducted to evaluate the unique contribution of psychological safety, teamwork and communication and team's trust on performance. Table 16 shows the results obtained from the regression. The results show an adjusted R^2 of .380 and no significant relationship between psychological safety, teamwork/communication and team's trust with performance.

Table 16

Regression weights and significance of Model 1

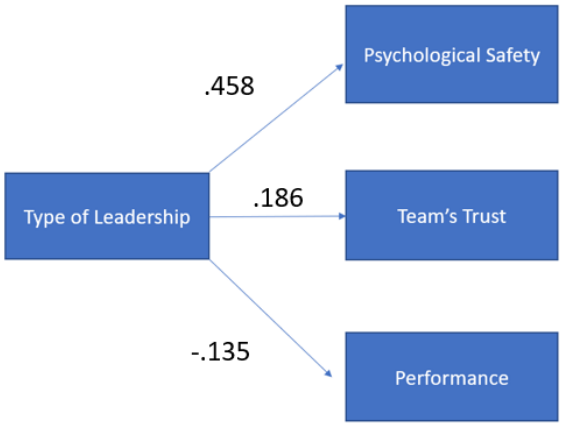
	Unstandardized B	Coefficients std. Error	Standardized coefficients Beta	Significance
Constant	-10.116	16.814	-.602	.580
Psychological Safety	-.477	2.299	-.064	.846
Teamwork/ communication	-.008	.006	-.440	.246
Team's trust	5.392	3.286	.539	.176

4.3.3 Model 2

The analysis for model 2 was conducted by using partial correlation controlling for the difficulty of the procedure and length of the surgery. The IWD measure indicating the type of leadership used was correlated with psychological safety, team's trust and performance (Figure 9).

Figure 9

Diagram of Model 2 with the Corresponding Correlation Coefficients



2a. Leadership and Psychological Safety

The measure of Importance Weighted Density was correlated with the aggregated scores of Psychological Safety. Results show a non-significant positive correlation between leadership and psychological safety r=.458, p=.317.

2b. Leadership and Team's Trust

The measure of Importance-Weighted Density was correlated with the aggregated scores of team's trust. Results show a non-significant positive correlation between leadership and team's trust r=.186, p=.165

2c. Leadership and Performance

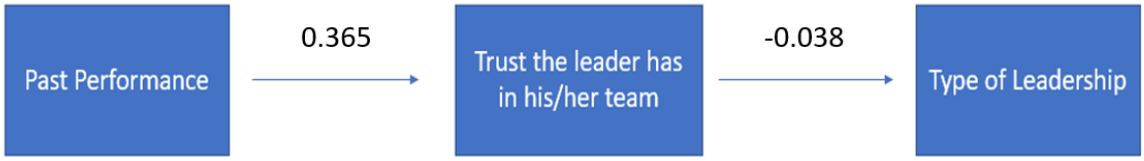
The measure of Importance-Weighted Density was correlated with the scores of performances. Results show a non-significant negative correlation between leadership and performance r=-.135, p=.187.

4.3.4 Model 3

The analysis for model 3 was conducted using path analysis in Lisrel. Past performance was modeled to have a direct effect on the trust the surgeon has in his/her team and this was then modeled to have a direct effect on the type of leadership used by the surgeon (Figure 10). These measures were individual-level measures.

Figure 10

Diagram of Model 3 with the Corresponding Beta Coefficients



The regression coefficient between past performance and trust the leader has in his/her team is β= 0.356, with a t-value of 5.430. The regression coefficient between trust the leader has in his/her team and type of leadership is β= -0.038, with a t-value of -0.707.

The maximum likelihood ratio Chi-Square is 1.722 (p= 0.189), the root mean square error of approximation (RMSEA) is .347, indicating that the model does not fit well and the standardized root mean square (SRMR) is 0.080 which is right on the cut off value of .08.

4.3.5 Discussion of Models

Model 1 shows the relationships between the constructs of psychological safety, teamwork/communication, team's trust, and performance. The results show that there is no correlation between psychological safety and team's performance (r=-.038). Interestingly, as psychological safety increases communication does as well (r=.431). We furthered this relationship to see if there was a difference in levels of psychological safety with what was being communicated. The results show that psychological safety increases as relational communication is taking place (r = .382) and it decreases when directive communication is taking place (r=-.220). Although these findings are not significant, they seem to be in line with previous studies conducted by Edmondson (2003). Team's trust is significantly correlated with communication

(r=.694, p=.053), and interestingly, the findings show that team's trust is positively correlated with relational communication (r=.239) and negatively correlated with directive communication (r = -.263). These findings mirror the ones previously addressed with psychological safety and the type of communication (relational vs. directive). The regression of psychological safety, teamwork/communication and team's trust on performance shows no significant relationship.

Model 2 shows that the type of leadership used is positively correlated with psychological safety (r=.458) with team's trust (r=.186) and negatively correlated with performance (r=-.135). These results seem to indicate that when a shared leadership approach is used there are higher levels of psychological safety and team's trust, however, performance decreases. Caution is needed when interpreting these results because they are all non-significant.

In model 3 we explored the relationship between past performance and the trust the leader has in his/her team and if this in turn affects the type of leadership the surgeon utilizes with the use of path analysis. The results are promising, although the sample size was very small (n= 6, t-critical value = 2.015). The results show that the surgeon's perceived past performance of the team does have a significantly effect on the levels of trust the leader has in his/her team (β= 0.356, t = 5.430). There appears to be a negative non-significant relationship between the trust the leader has in his/her team with the type of leadership used (β= -0.038, t=-0.707). This path model shows that when the surgeon perceives that the team he/she has just worked with has done exceptional work in the past, his/her ratings of trust in the team are higher, but it does not support the relationship between the surgeon's trust in the team and the type of leadership used.

One of the main contributions of this study to the literature are the results from model 3. To our knowledge, there has not been research exploring the relationships of past performance and the trust the surgeon has in his/her team. This relationship is very much intuitive because a

designated leader would not cede leadership to team members whom he/she does not trust, and trust is built on past experiences with those team members. These results should be furthered with a larger sample size to understand if they are indeed generalizable. Another interesting result from this analysis is the relationship between leadership and performance. Leadership research is divided when it comes to determining what type of leadership is better for higher performance. On one hand, researchers argue that shared leadership is beneficial for team effectiveness (Klein et al., 2006; Kunzle et al., 2010) and on the other hand, researchers argue that it is hindering performance (D'Innocenzo, Mathieu & Kukenberger, 2016; Pasarakonda et al., 2020). The results from this study support the notion that shared leadership does not facilitate performance for highly complex tasks and that an autocratic type of leadership may get the tasks done more efficiently and effectively. However, what remains unclear is to what extent should the dynamics of surgical teams favor performance over psycho-social constructs, such as psychological safety and trust. Further studies should address this issue and understand if there is an optimal balance that can be achieved to have both high performing and satisfied teams.

5 Conclusion

Over the last 20 years, researchers, clinicians and practitioners have worked to address safety during the high-risk perioperative period, creating well-intentioned and evidence-based interventions, such as TeamSTEPPS (Stead et al., 2009), briefings and safety checklists (Conley, Singer, Edmondson, Berry, & Gawande, 2011; Haynes, et al., 2009). However, few look at how leadership behaviors change temporally in an environment such as the operating room. For example, the time out and the surgical safety checklist represents a redundant system that enables clinical practitioners to catch non-routine events early on. It may well be that for this perioperative pause to be effective, a shared situational awareness would have to be implemented. The results of this research study showed what type of leadership style takes place during the different phases of the perioperative process. The communication patterns are spread across most of the team members during the time out and during cannulation indicating a more shared leadership approach during these phases. Communication patterns are reserved to a select few during the procedure and the start and end of the perfusion. This suggests that surgical team members use distinct leadership styles depending on the task. There are many types of communications taking place during the surgical procedure but instructions and providing assistance are the most frequent suggesting that the operating room is both a directive and collaborative environment. With the model analysis we were interested in understanding the relationship between psychological safety, team's trust and teamwork/communication. The results from the model analysis show that there is a significant relationship between teamwork/communication and trust. The more the team trust each other the higher the frequency in communication. We were then interested if these three constructs predicted performance. The results show that performance is not predicted by psychological safety,

teamwork/communication and team's trust. We then examined the relationship of the type of leadership with psychological safety, performance and trust. Again, there was no significant relationship and therefore no conclusions can be drawn from this model. It is important to note that these models are not separated by phases of the surgery and as seen in the social network analysis, the leadership is dynamic over the course of the operation. Although these findings are not significant there may be more insight to gain if we parse the leadership flow by phase. The last question that we sought to answer was the one regarding the relationship between the surgeon's perception of past performance of the team he/she just worked with and if this had an effect on the trust that the surgeon had in that team. This was proven to be significant and an interesting avenue to peruse. However, there was no evidence that the trust the surgeon had in the team affected the type of leadership used during the surgery. The findings are underpowered, however, if more research is conducted on the questions posed in this study, it can inform I/O Psychology practitioners to develop leadership trainings based on empirical evidence of team psychological processes that take place in action teams during highly structured, yet high stress situations.

5.1 Limitations and Future Directions

There are several limitations to this study: The sample size is extremely small; therefore, these results are non-generalizable. We also acknowledge that we had to omit some questionnaires from the analysis because the participant did not coherently respond to the reverse phrased questions, thereby lowering the interrater agreement. In future data collection, one way to avoid this issue is to modify the reverse phrased questions. Related to this issue was the use of two subscales for trust. The correlation between the perceived trustworthiness sub-scale and the monitoring behavior sub-scale was -.111. This low and negative correlation may be because the

monitoring behavior scale has more reverse questions and therefore participants did not respond coherently about their feeling of trust within the team. In the future, we will consider only using the perceived trustworthiness scale during data collection. There are some high correlations for the constructs of psychological safety and team's trust between teams (see table 6). This may be because those responding to the questionnaire about one surgery are also present and filling out the questionnaire for other surgeries and therefore their responses may be similar for both surgeries. In the future, we will account for the overlap in personnel during multiple surgeries in the analysis.

The past performance measure is problematic for multiple reasons. First, the surgeon does not work with the same team each time and he/she does not work with a new team each time. Therefore when asked to rate the past performance of the team the surgeon has just worked with, the surgeon may be more familiar with some surgical staff members over others, however this distinction is not captured by the measure of past performance. Second, the surgeon is asked to respond to this questionnaire (assessing how the team has performed in the past) at the end of the surgical procedure and therefore there may be confounding factors as to how the current procedure went and the perception the surgeon has of the past performance of the team. It would be better to ask the surgeon his/her perception of past performance of that team before the surgical procedure begins and potentially restrict the questionnaire to assess the past performance of the core group (circulator nurse, scrub nurse, anesthesiologist and perfusionist) rather than the entire team. Third, the surgeon may be basing the perception of past performance of the team on the outcome of the patient and not the teamwork and communication of the team. In that case, if the patient is very sick and the procedure does not go as planned, the surgeon may be rating the

performance of the team lower when it was actually the acuity of the patient that lead to a bad outcome.

For the index of patient criticality, we sought to use the ASA score which is a measure of the patient's acuity used by the anesthesiologist team. Although this would be a good measure to use in general surgery, most patients who have cardiovascular procedure have a high ASA score. In fact, all patients had an ASA score of 4 and therefore this measure did not provide any variability for the patient's acuity. Another measure should be used to determine the patient acuity and be used in the analysis.

Furthermore, the start and end of the social network may not be the same for each surgical case because the language used by the different teams may vary. To resolve this issue, the researcher coded the entirety of the operation so that a post-hoc identification of the five critical steps was identified at a later time. There may also be a confounding factor in terms of interactions between the surgeon and the scrub nurse. The scrub nurse hands the instruments and helps the surgeon when no resident is present. When the scrub nurse has worked extensively with a surgeon, there is no need for the surgeon to ask for a specific instrument because the scrub nurse already knows what the surgeon needs and therefore no interactions take place. A team familiarity question may help resolve this confounding factor.

Regarding the social network, it would be interesting to have a specific performance measure for each phase in order to evaluate what type of leadership is best at different times of the surgery. For example, during the time out a shared type of leadership approach may be best, whereas during the start and end of perfusion a more autocratic (or directive) type of leadership approach facilitates these task heavy phases.

Another limitation of this study was the absence of a second coder for the live interactions among team members. Not having a second coder made it impossible to obtain a reliability measure of the coding. However, in future data collection another student will be engaged in the observations and thus, we will be able to obtain a reliability measure.

An observed difference between CRMH and MGH team members is that CRMH has residents whereas MGH has fellows assisting the surgeons. Fellows have more autonomy compared to residents who are always supervised by the attending. Although these differences may contribute to different trust levels, for simplicity, we will treat residents and fellows as the same professional role when comparing the data of the two sites in a future study. In the future we would like to make this a multi-site study with Massachusetts General Hospital and to use the data collected to find causal relationship between the constructs measured in this study.

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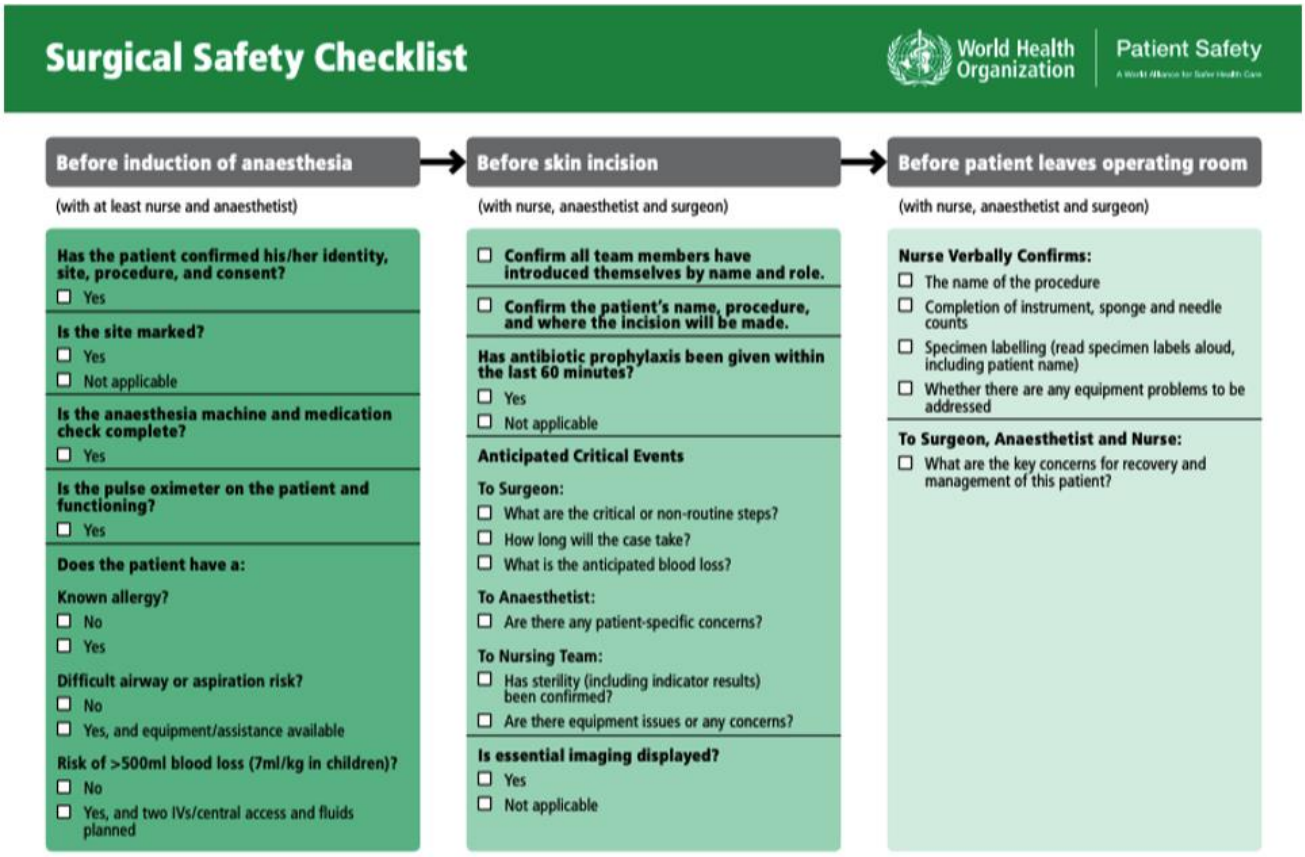
Appendix A

Schematics of Methods

Construct	When is it measured	How is it measured	Devices used to collect data
Leadership	During the procedure	Who is talking to whom with live coding of the interactions.	iPad
Psychological safety	At the end of the procedure	Edmondson (1999) Psychological safety scale	Paper and pencil questionnaire
Trust	At the end of the procedure	Costa and Anderson (2011) trust scale	Paper and pencil questionnaire
Communication and teamwork	During the procedure	Co-Act scale (Kolbe et al., 2012): interactions will be coded based on the scale	iPad
Performance	During the procedure and post-hoc	Number of times circulator nurse leaves the room; length of bypass time and length of surgery	iPad
Past Performance	At the end of the procedure	Edmondson (1999) performance scale	Paper and pencil questionnaire

Appendix B

World Health Organization Surgical Checklist



Surgical Safety Checklist

World Health Organization | Patient Safety

Before induction of anaesthesia

(with at least nurse and anaesthetist)

Has the patient confirmed his/her identity, site, procedure, and consent?
- ☐ Yes

Is the site marked?
- ☐ Yes
- ☐ Not applicable

Is the anaesthesia machine and medication check complete?
- ☐ Yes

Is the pulse oximeter on the patient and functioning?
- ☐ Yes

Does the patient have a:

Known allergy?
- ☐ No
- ☐ Yes

Difficult airway or aspiration risk?
- ☐ No
- ☐ Yes, and equipment/assistance available

Risk of >500ml blood loss (7ml/kg in children)?
- ☐ No
- ☐ Yes, and two IVs/central access and fluids planned

Before skin incision

(with nurse, anaesthetist and surgeon)

- ☐ **Confirm all team members have introduced themselves by name and role.**
- ☐ **Confirm the patient's name, procedure, and where the incision will be made.**

Has antibiotic prophylaxis been given within the last 60 minutes?
- ☐ Yes
- ☐ Not applicable

Anticipated Critical Events

To Surgeon:
- ☐ What are the critical or non-routine steps?
- ☐ How long will the case take?
- ☐ What is the anticipated blood loss?

To Anaesthetist:
- ☐ Are there any patient-specific concerns?

To Nursing Team:
- ☐ Has sterility (including indicator results) been confirmed?
- ☐ Are there equipment issues or any concerns?

Is essential imaging displayed?
- ☐ Yes
- ☐ Not applicable

Before patient leaves operating room

(with nurse, anaesthetist and surgeon)

Nurse Verbally Confirms:
- ☐ The name of the procedure
- ☐ Completion of instrument, sponge and needle counts
- ☐ Specimen labelling (read specimen labels aloud, including patient name)
- ☐ Whether there are any equipment problems to be addressed

To Surgeon, Anaesthetist and Nurse:
- ☐ What are the key concerns for recovery and management of this patient?

Appendix C

Measurement Tools

Trust scale (Costa & Anderson 2011)
The full scale is provided below

Propensity to trust:

1. Most people in this team do not hesitate to help a person in need.
2. In this team most people speak out for what they believe in.
3. In this team most people stand behind their convictions.
4. The typical person in this team is sincerely concerned about the problems of others.
5. Most people will act as "Good Samaritans" if given the opportunity.
6. People usually tell the truth, even when they know they will be better off by lying.

Perceived trustworthiness

7. In the team people can rely on each other.
8. We have complete confidence in each other's ability to perform tasks.
9. In this team people will keep their word.
10. There are some hidden agendas in this team.
11. Some people in this team often try to get out of previous commitments.
12. In this team people look for each other's interests honestly.

Cooperative behaviors

13. In this team we work in a climate of cooperation.
14. In this team we discuss and deal with issues or problems openly.
15. While taking a decision we take each other's opinion into consideration.
16. Some people hold back relevant information in this team.
17. In this team people minimize what they tell about themselves.
18. Most people in this team are open to advice and help from others.

Monitoring behaviors

19. In this team people watch each other very closely.
20. In this team people check whether others keep their promises.
21. In this team most people tend to keep each other's work under surveillance.

Psychological Safety scale (Edmondson, 1999):

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

Past performance scale (Edmondson, 1999)

1.This team usually meets of exceeds expectations
2. This team usually does superb work
3. Critical quality errors usually occur frequently in this team's work
4. This team keeps getting better and better.

Co-Act Scale (Kolbe et al., 2012)

	Category	Definition	example
Explicit action coordination	Instruction	Includes directives, commands or assignments of subtasks	"give him the fentanyl"
	Speaking up	Question sand direct remarks concerning procedure and further courses of action	"are you sure you want to intubate right now?"
	planning	Include verbalizations of non-immediate considerations regarding what should be done and when	"when we have finished intubation, we will call for an OR nurse"
Implicit action coordination	monitoring	Coded when a team member observes the actions of his/her colleagues (if team member observes environment gather information)	Team member watches what another team member is doing
	Action-related talking-to-the-room	Includes comments on the performance of own current behavior	"I'm turning the alarm down"
	Provide assistance	Includes task-relevant action completed without being asked to do so backing team members up	After the physician announces he/she is going to intubate, the nurse holds out the laryngoscope
Explicit information coordination	Information request	Coded if one team member directly asks another member for (task-relevant) information	"where is the defibrillator?"
	Information evaluation	Includes statements expressing doubts or assurance regarding the accuracy or source of information	"are you sure he has no allergies?"
	Information on request	Coded if a team member answers a (task-relevant) question asked by another	"the defibrillator is in the operating room next door".
	Opinion request	Coded if a team member asks for a opinion	"What do you think if we do x instead of y?"
	Gather information	Coded if a team member actively gathers information from the environment (but not	Reading indicators on a monitor or patient's chart

Implicit information coordination		from other colleagues monitoring)	
	Information related talking-to-the-room	Coded if team member appeared to address a communication not to a specific team member but to the room at large	“he seems to feel better now”
	Information without request	Providing information to a team member without being asked to do so	“just to let you know, this patient might have a severe reaction to the anesthetic”

Questionnaire

What is your professional role?

☐ anesthesiologist ☐ resident
☐ circulating nurse ☐ scrub tech
☐ fellow ☐ student
☐ perfusionist ☐ surgeon
☐ physician assistant ☐ other _____

Mother's name 2 first letters		Father's name 2 first letters		Day of birth

How difficult was this procedure for you?

Very easy		Neutral		Very difficult
☐	☐	☐	☐	☐

During this procedure, how did you feel about the following:

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

Recall when you have worked with this team **in the past**:

	very inaccurate			neutral		very accurate	
7. This team usually meets or exceeds expectations.	☐	☐	☐	☐	☐	☐	☐
8. This team usually does superb work.	☐	☐	☐	☐	☐	☐	☐
9. Critical quality errors usually occur frequently in this team's work.	☐	☐	☐	☐	☐	☐	☐
10. This team keeps getting better and better.	☐	☐	☐	☐	☐	☐	☐

How do you feel about the following?

	very inaccurate			neutral		very accurate	
11. In this team people can rely on each other.	☐	☐	☐	☐	☐	☐	☐
12. We have complete confidence in each other's ability to perform tasks.	☐	☐	☐	☐	☐	☐	☐
13. There are some hidden agendas in this team.	☐	☐	☐	☐	☐	☐	☐
14. In this team people look for each other's interests honestly.	☐	☐	☐	☐	☐	☐	☐
15 In this team people watch each other very closely.	☐	☐	☐	☐	☐	☐	☐
16. In this team people check whether other keep their promises.	☐	☐	☐	☐	☐	☐	☐
17. In this team most people tend to keep each other's work under surveillance.	☐	☐	☐	☐	☐	☐	☐

Overall, how do you feel about the following?

	very inaccurate			neutral		very accurate	
18. The use of the surgical safety checklist during the time out is useful.	☐	☐	☐	☐	☐	☐	☐
19. During the procedure the time out helped foresee one or more unexpected events.	☐	☐	☐	☐	☐	☐	☐
20. I see the time out as an opportunity for me to take on a leadership role.	☐	☐	☐	☐	☐	☐	☐

Appendix D

Social Network Analysis Measure Definitions

Importance Weighted Density

"The IWD takes into account the magnitude of a node's incoming ties, the relative centrality of that node compared to others, as well as the relative influence and centrality of contacts from whom ties emerge." (Lemoine et al., 2020)

Density

"*The Density of a network is a graph or network level measure of the ratio of the number of links present given the total number of links possible. In a dense network, there are many links. In a sparse network, there are relatively few links"* (McCulloh et al., 2013)

Betweenness Centrality

"The Betweenness Centrality of node v in a network is defined as: across all node pairs that have a shortest path containing v, the percentage that pass through v. When the data is weighted, the higher the weight the more value the link has. Individuals or organizations that are potentially influential are positioned to broker connections between groups and to bring to bear the influence of one group on another or serve as a gatekeeper between groups. This agent occurs on many of the shortest paths between other agents. The scientific name of this measure is betweenness centrality and it is calculated on agent by agent matrices" (Carley, 2014)

Closeness Centrality

"The closeness of a node to the other nodes in a network (also called out-closeness). Loosely, Closeness is the inverse of the sum of distances in the network from a node to all other nodes" (Carley, 2014)

Centrality Eigenvector

"Leaders of strong cliques are individuals or organizations who are collected to others that are themselves highly connected to each other. In other words, if you have a clique then the individual most connected to others in the clique and other cliques, is the leader of the clique. Individuals or organizations who are connected to many otherwise isolated individuals or organizations will have a much lower score in this measure then those that are connected to groups that have many connections themselves. The scientific name of this measure is eigenvector centrality and it is calculated on agent by agent or organization by organization matrices" (Carley, 2014)

Centrality total degree

"Individuals or organizations who are 'in the know' are those who are linked to many others and so, by virtue of their position have access to the ideas, thoughts, beliefs of many others. Individuals who are 'in the know' are identified by degree centrality in the relevant social

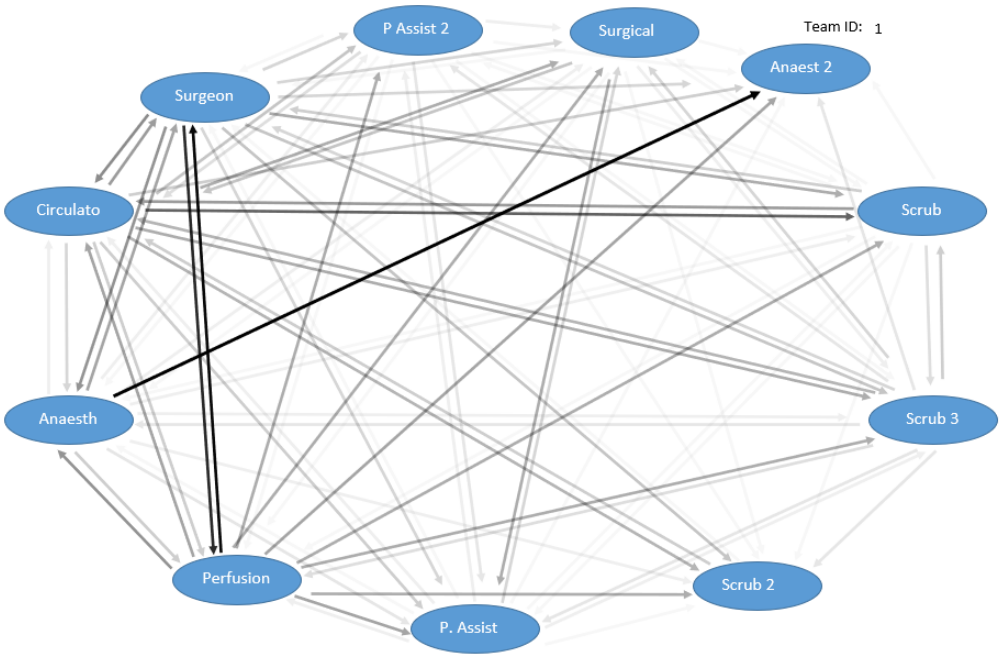
network. Those who are ranked high on this metrics have more connections to others in the same network. The scientific name of this measure is total degree centrality and it is calculated on the agent by agent matrices" (Carley, 2014)

Appendix E

Overall Social Networks with Measures

The following shows the social networks created with all the surgical staff members during each surgery observed. A darker link between two agents represents a higher number of interactions between the two agents, whereas the lighter the link, the fewer the interactions. Descriptive statistics are provided after each figure. Note: the program used to display the figure only allowed up to 11 agents to be displayed but all analysis was conducted with the actual number of agents present.

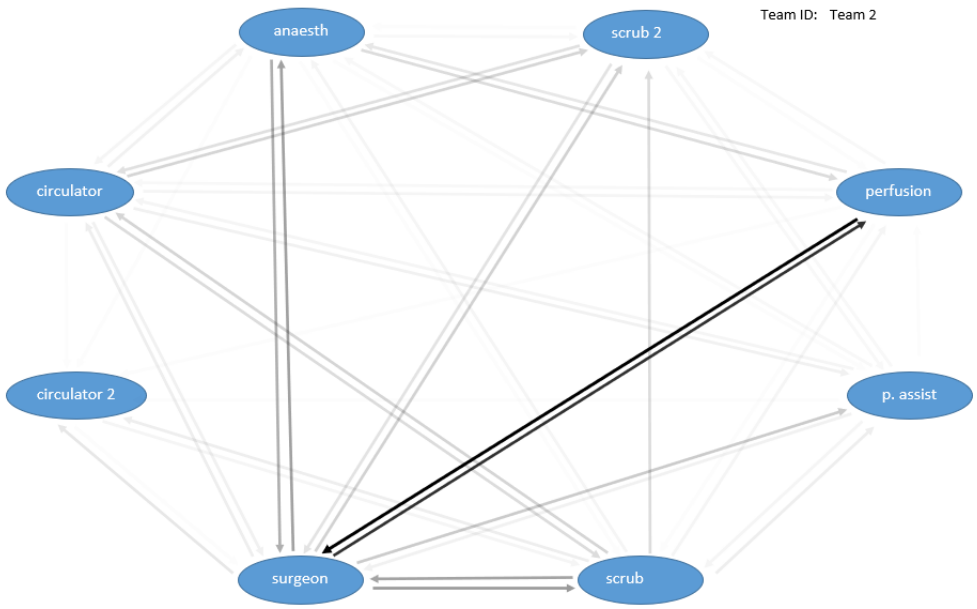
Team 1 (surgeon 1):



size: 11; density: 0.836364; IWD: 0.143

Measure	Min	Mean	Max	Std.Dev
Betweenness centrality	0	0.045	0.112	0.041
Closeness centrality	0.003	0.372	0.714	0.268
Centrality eigenvector	0.234	0.400	0.684	0.146
Centrality total degree	0.068	0.151	0.279	0.075

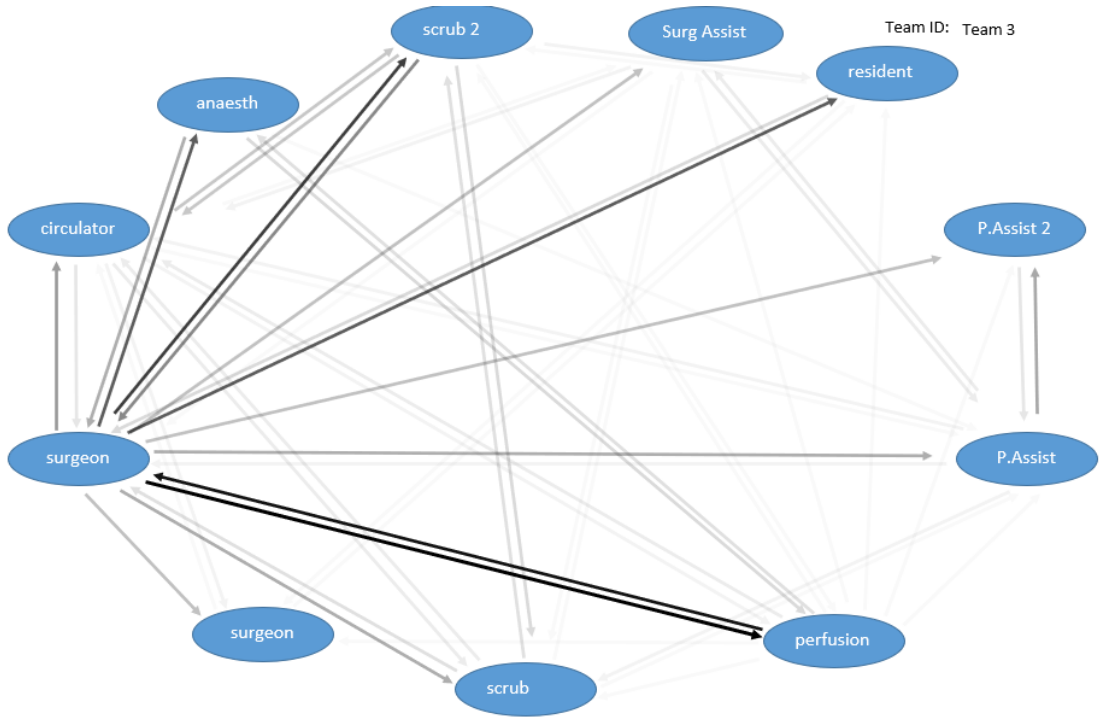
Team 2 (surgeon 1):



Size 8; density 0.875; IWD .0927

Measure	Min	Mean	Max	Std.Dev
Betweenness centrality	0.024	0.112	0.238	0.072
Closeness centrality	0.125	0.369	0.583	0.163
Centrality eigenvector	0.109	0.408	0.948	0.289
Centrality total degree	0.020	0.106	0.288	0.080

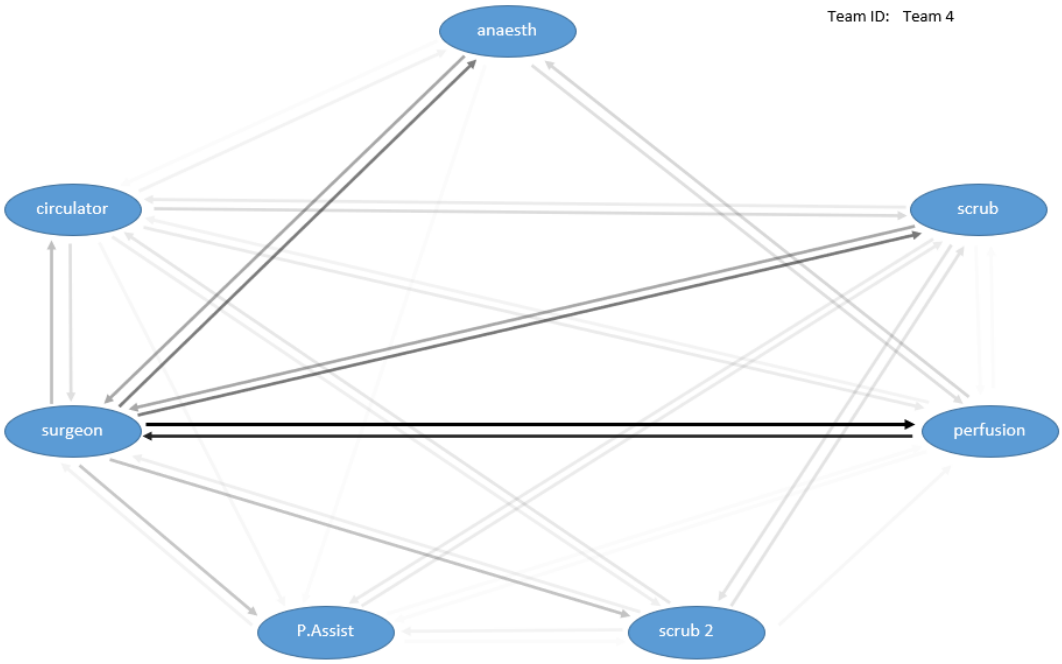
Team 3 (surgeon 2):



Size: 12; density: 0.439394; IWD: 0.0806

Measure	Min	Mean	Max	Std.Dev
Betweenness centrality	0	0.111	0.382	0.133
Closeness centrality	0.002	0.275	0.647	0.161
Centrality eigenvector	0.137	0.339	0.956	0.228
Centrality total degree	0.013	0.074	0.326	0.081

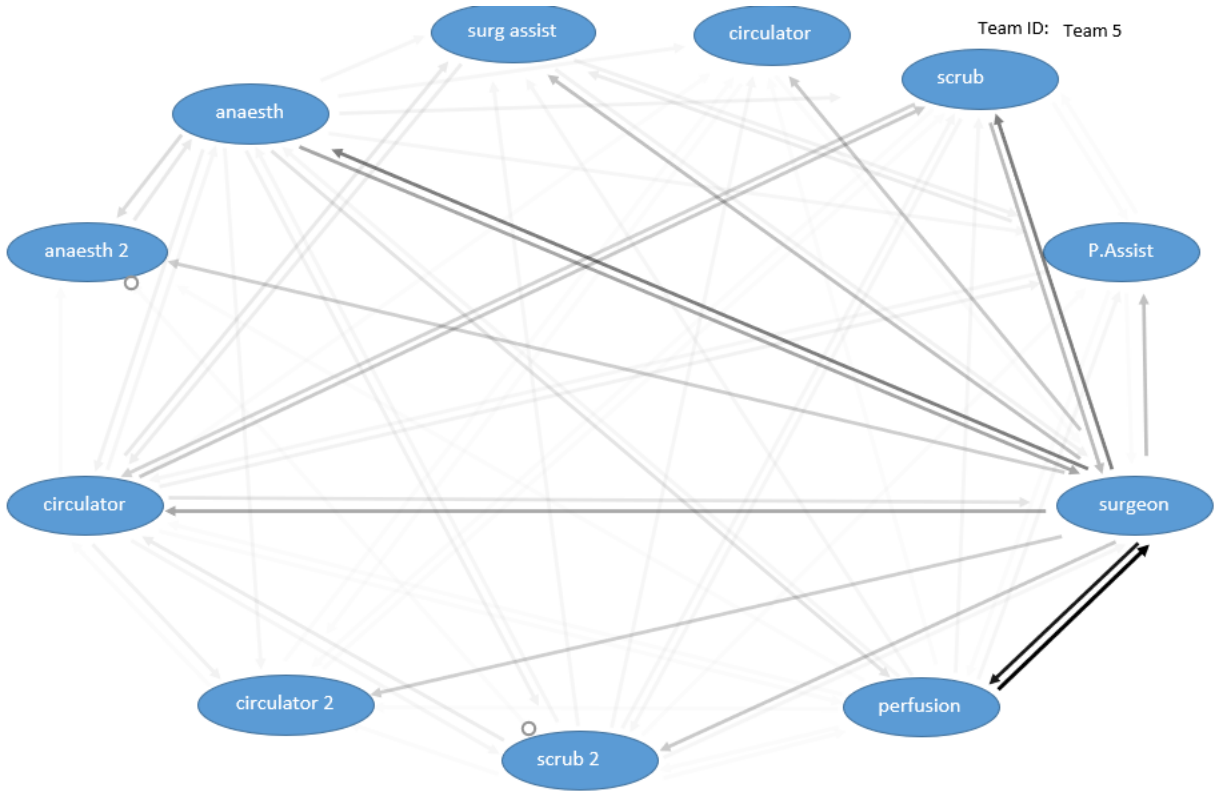
Team 4 (surgeon 2):



size: 7; density: 0.857143; IWD: 0.12994

Measure	Min	Mean	Max	Std.Dev
Betweenness centrality	0	0.167	0.567	0.198
Closeness centrality	0.065	0.357	0.500	0.137
Centrality eigenvector	0.196	0.467	0.952	0.261
Centrality total degree	0.047	0.142	0.378	0.106

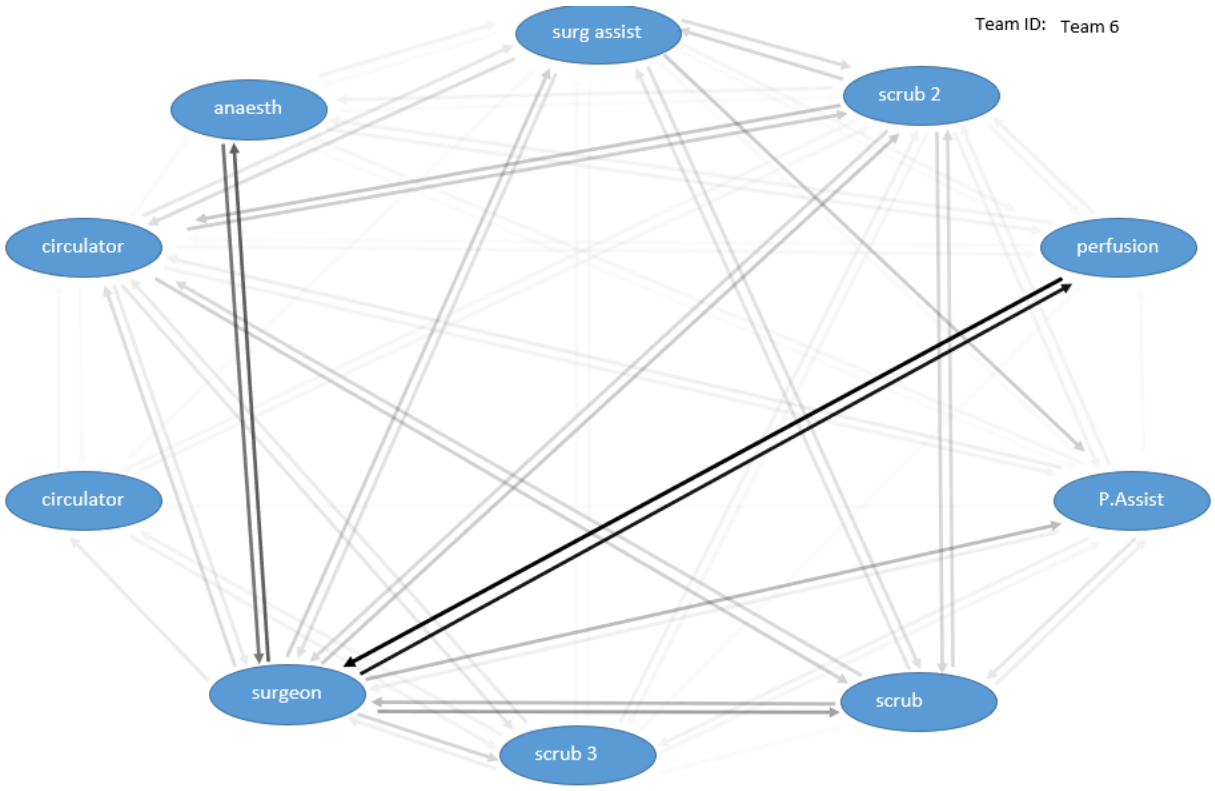
Team 5 (surgeon 3):



size:12; density:0.575758; IWD: 0.06578

Measure	Min	Mean	Max	Std.Dev
Betweenness centrality	0	0.070	0.228	0.073
Closeness centrality	0.001	0.389	0.688	0.206
Centrality eigenvector	0.154	0.333	0.943	0.236
Centrality total degree	0.017	0.061	0.255	0.065

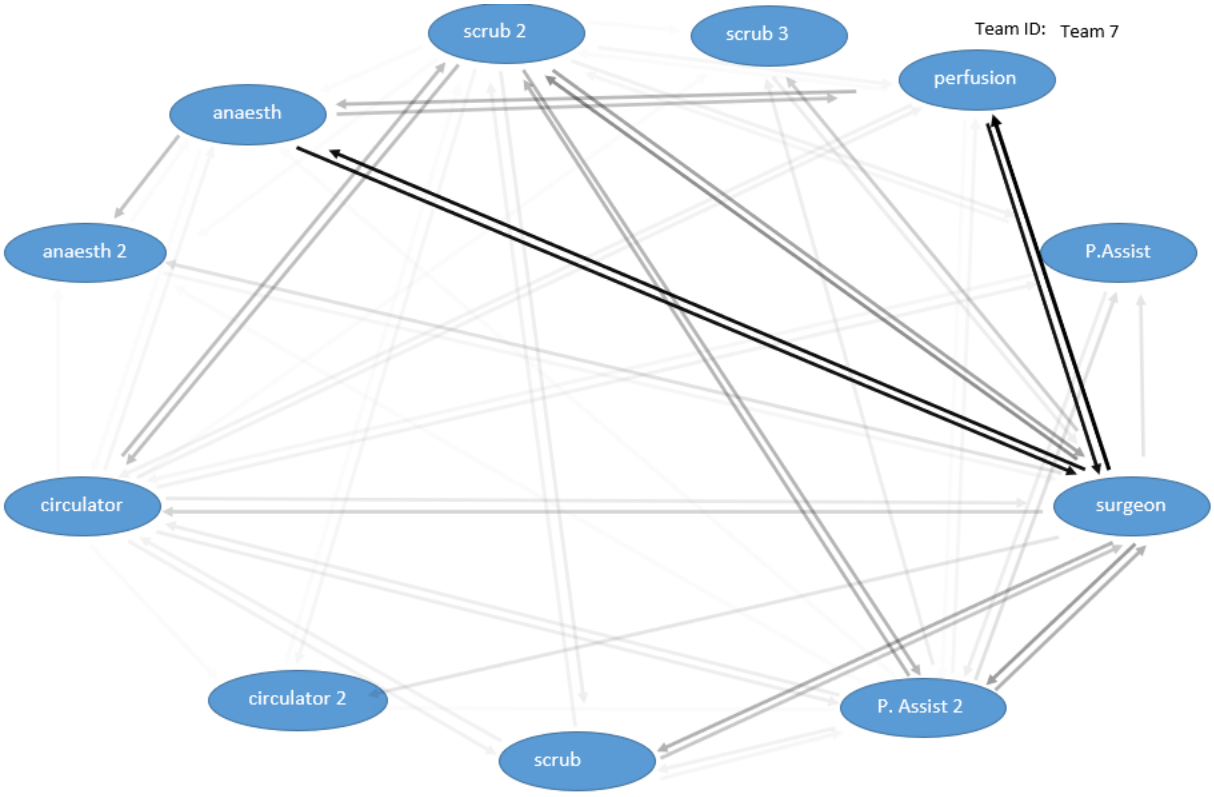
Team 6 (surgeon 4):



Size:10 ; density: 0.777778; IWD: 0.08488

Measure	Min	Mean	Max	Std.Dev
Betweenness centrality	0	0.117	0.226	0.076
Closeness centrality	0.134	0.351	0.500	0.112
Centrality eigenvector	0.067	0.371	0.939	0.249
Centrality total degree	0.016	0.095	0.289	0.071

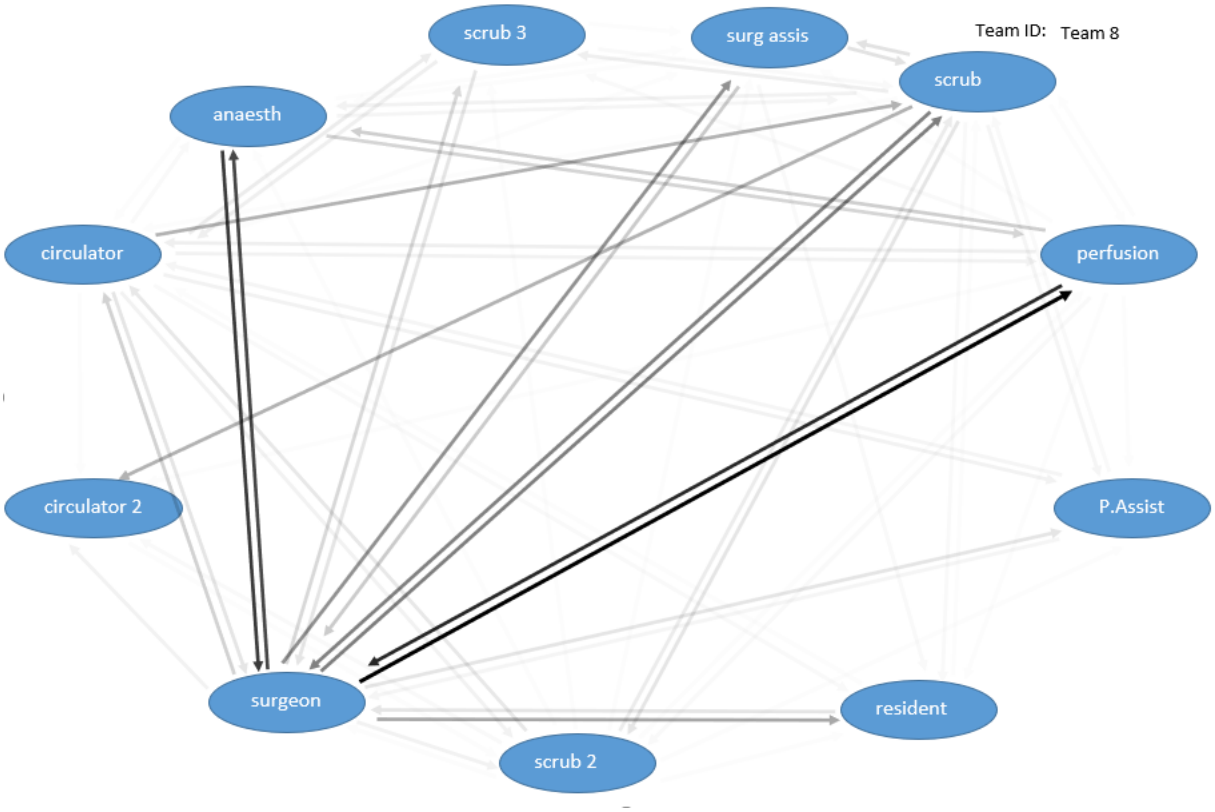
Team 7 (surgeon 5):



size: 12; density:0.5; IWD: 0.07920

Measure	Min	Mean	Max	Std.Dev
Betweenness centrality	0	0.105	0.265	0.087
Closeness centrality	0.122	0.348	0.524	0.127
Centrality eigenvector	0.065	0.309	0.931	0.267
Centrality total degree	0.008	0.076	0.310	0.082

Team 8 (surgeon 5):



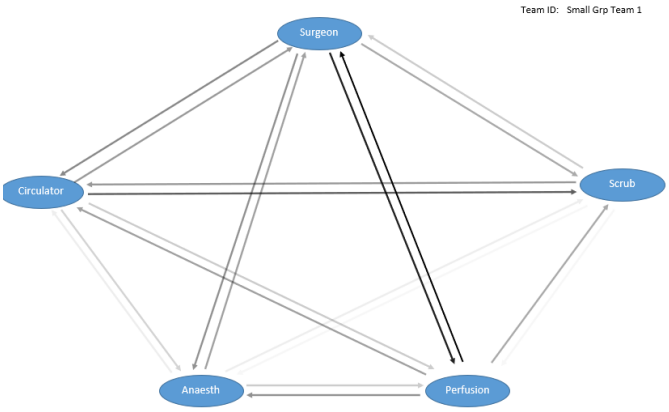
size:13; density:0.544872; IWD: 0.071069

Measure	Min	Mean	Max	Std.Dev
Betweenness centrality	0	0.094	0.261	0.095
Closeness centrality	9.737 e-04	0.379	0.800	0.201
Centrality eigenvector	0.056	0.294	0.941	0.259
Centrality total degree	0.006	0.060	0.268	0.068

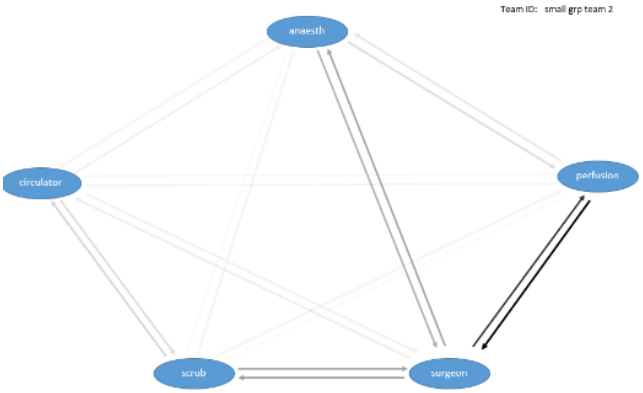
Appendix F

Core Team Social Networks

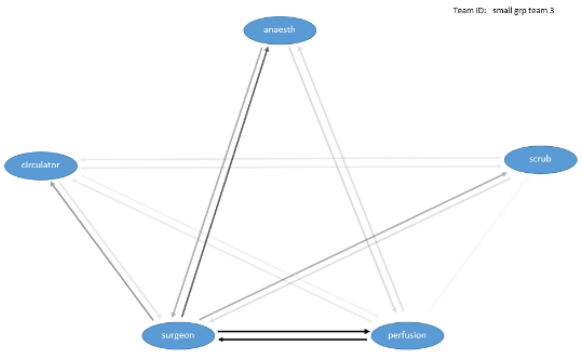
Team 1 (surgeon 1):



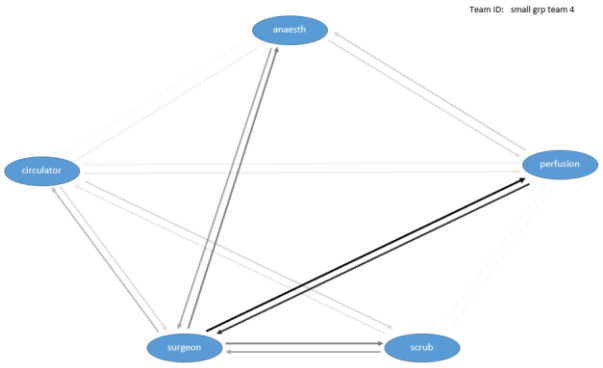
Team 2 (surgeon 1):



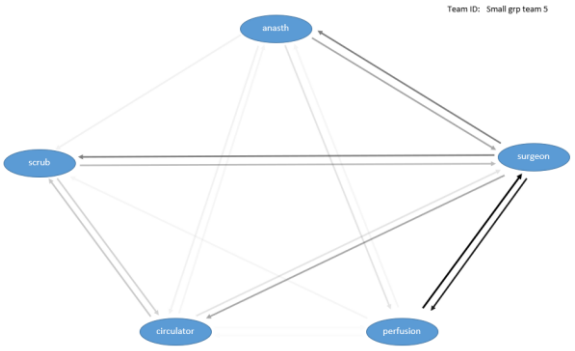
Team 3 (surgeon 2):



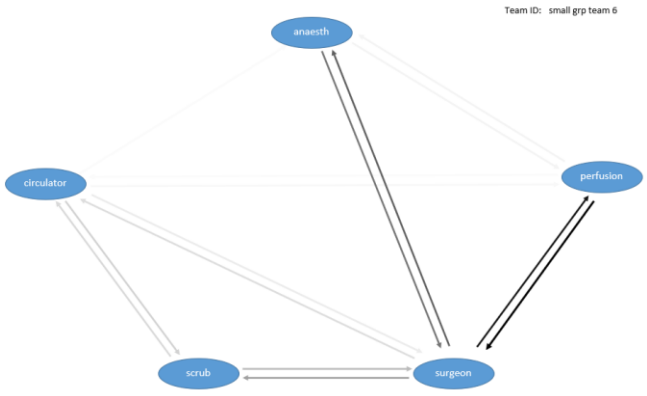
Team (surgeon 2):



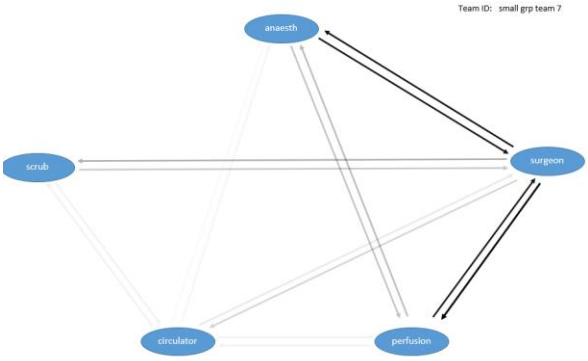
Team 5 (surgeon 3):



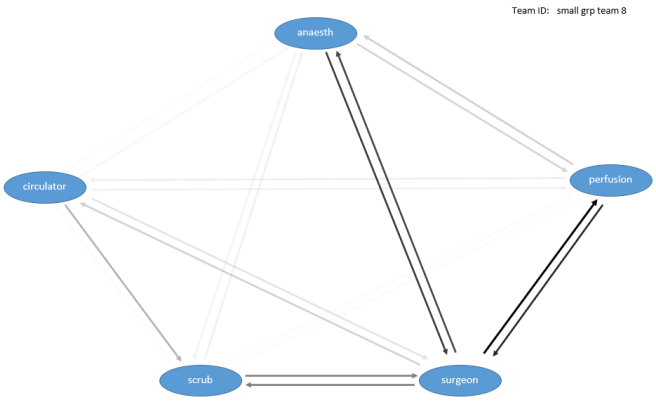
Team 6 (surgeon 4):



Team 7 (surgeon 5):



Team 8 (surgeon 5):

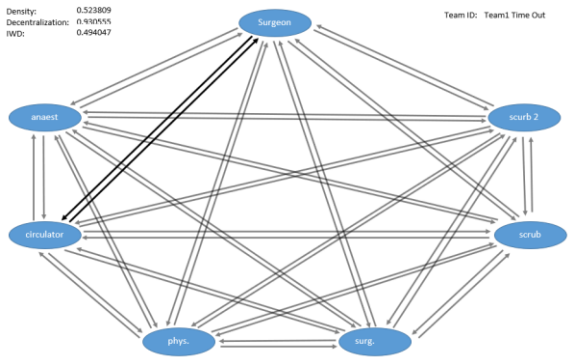


Appendix G

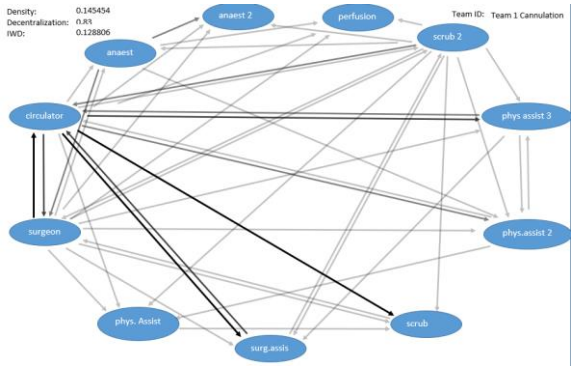
Social Network Analysis by Time

Team 1 (surgeon 1)

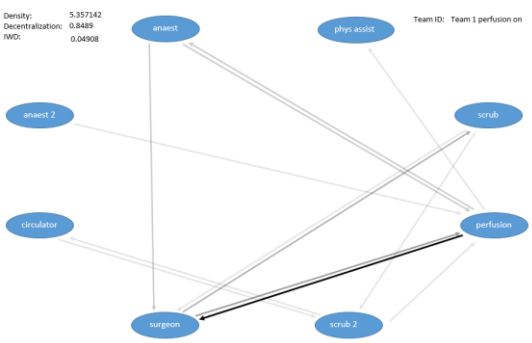
1. Timeout



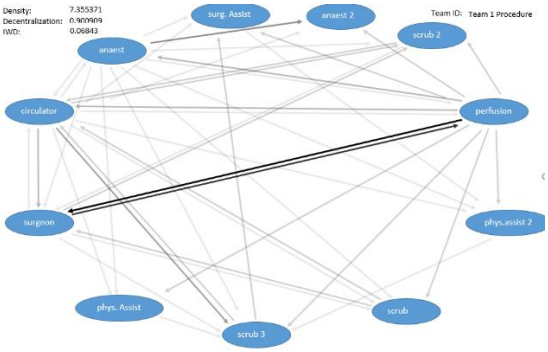
2. Cannulation



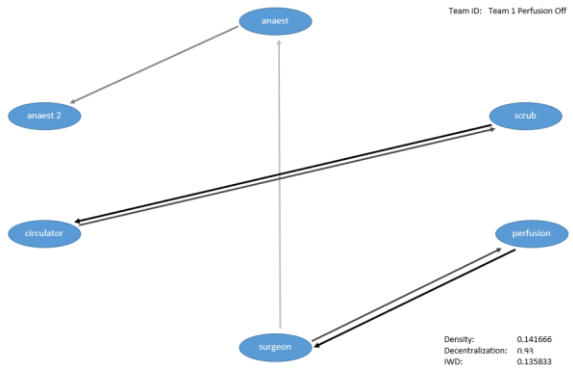
3. Start of perfusion



4. Procedure

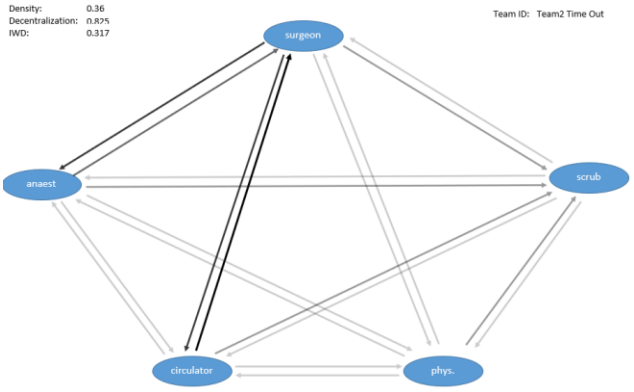


5. End of perfusion

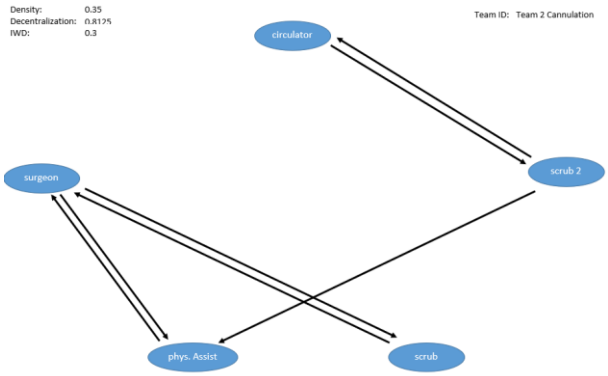


Team 2 (surgeon 1)

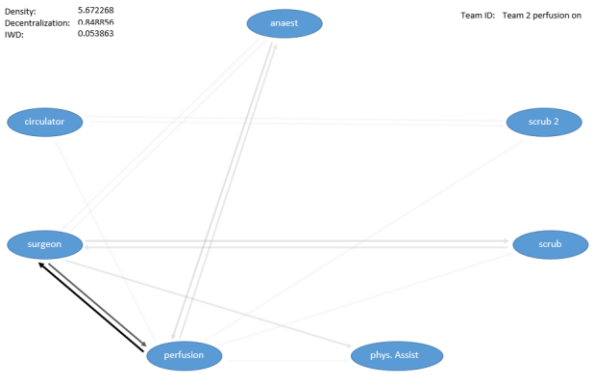
1.Timeout



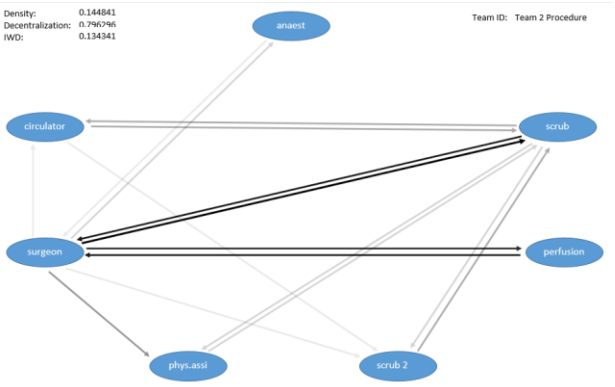
2. Cannulation



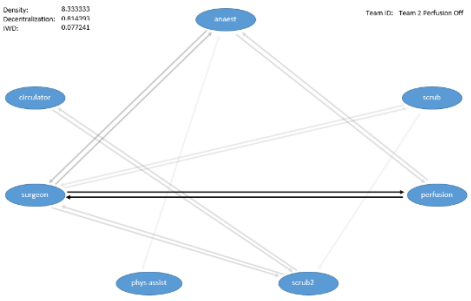
3. Start of perfusion



4. Procedure

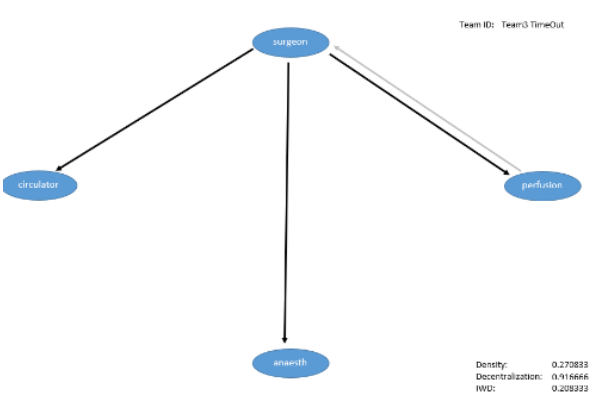


5. End of perfusion

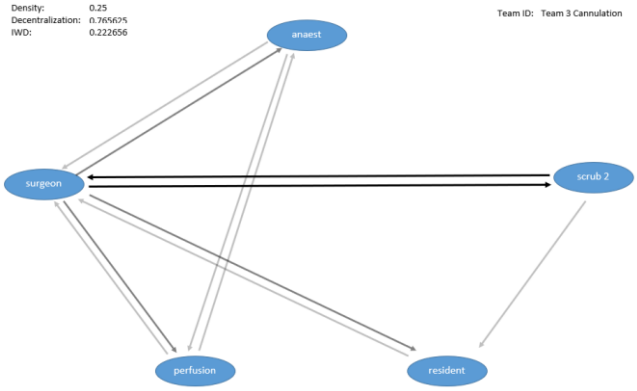


Team 3 (surgeon 2)

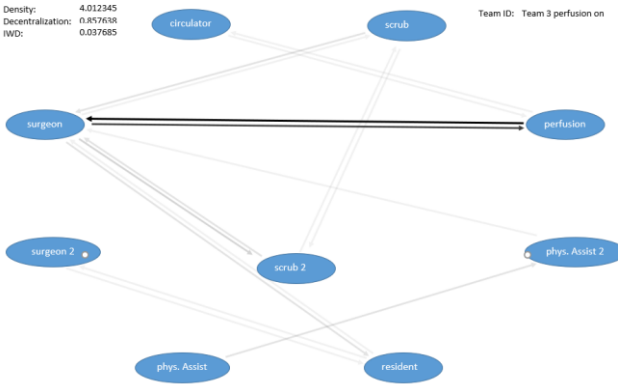
1.Timeout



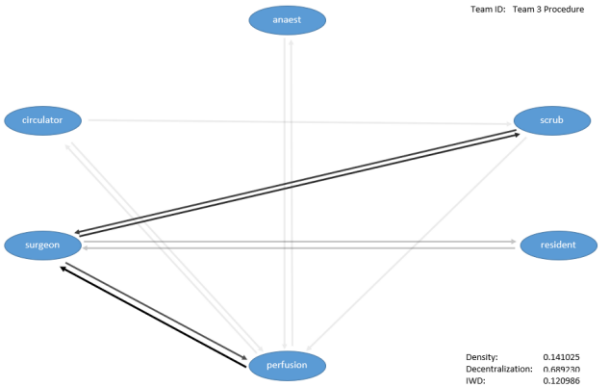
2. Cannulation



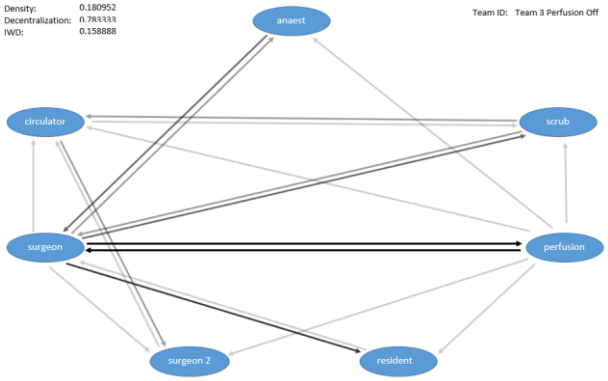
3.Start of perfusion



4. Procedure

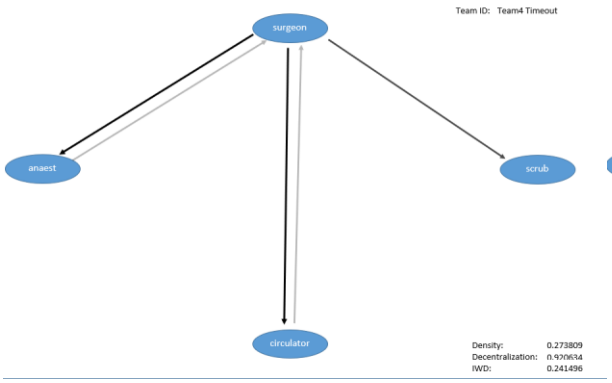


6. End of perfusion

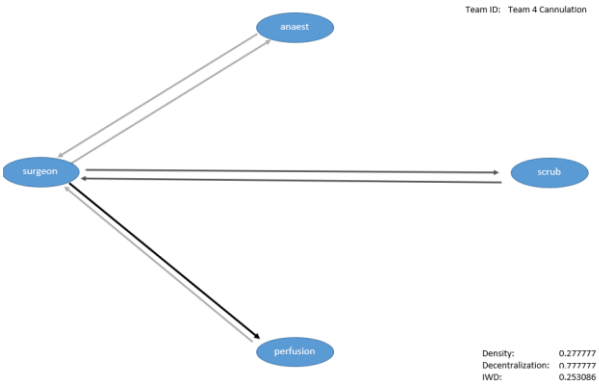


Team 4 (surgeon 2)

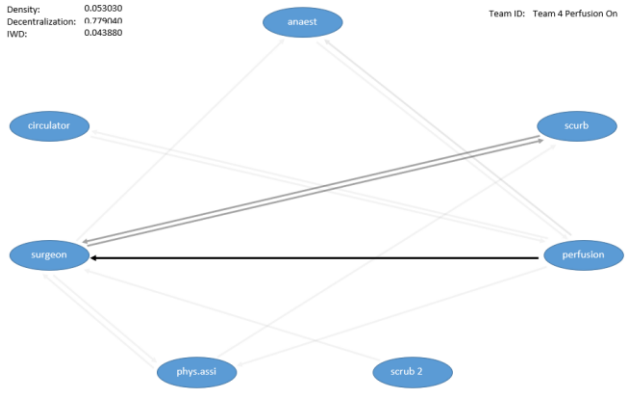
1.Timeout



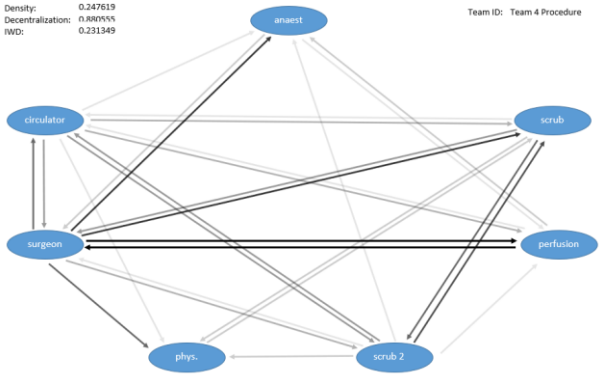
2. Cannulation



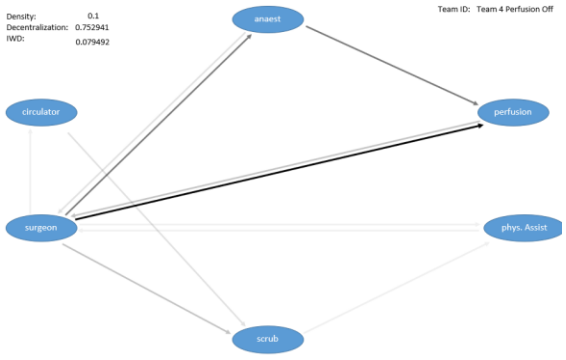
3. Start of perfusion



4. Procedure

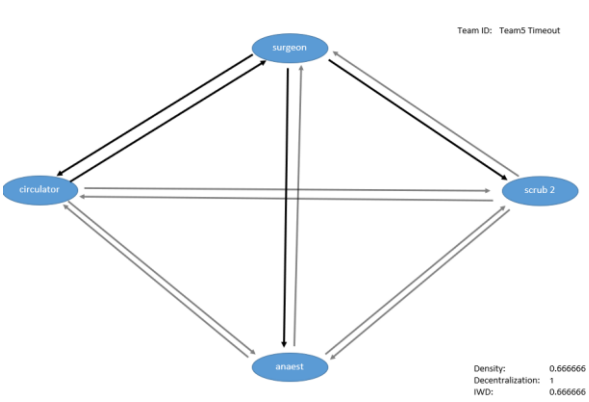


5.End of perfusion

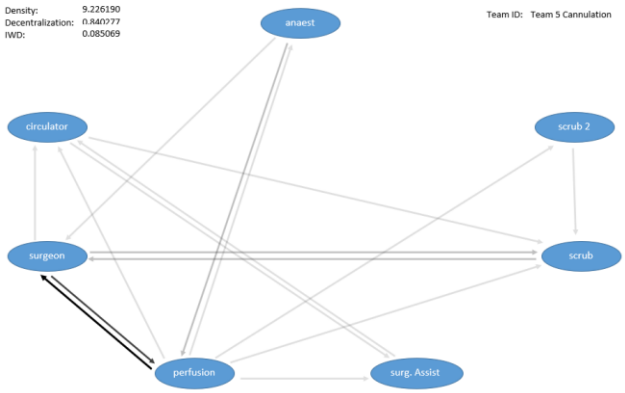


Team 5 (surgeon 3)

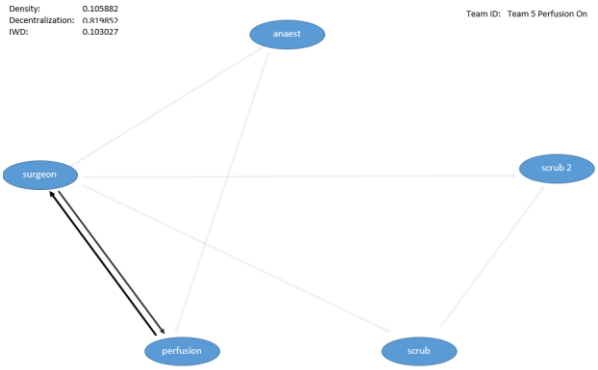
1.Timeout



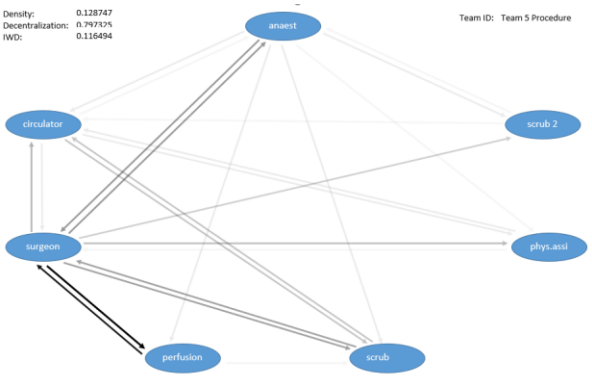
2. Cannulation



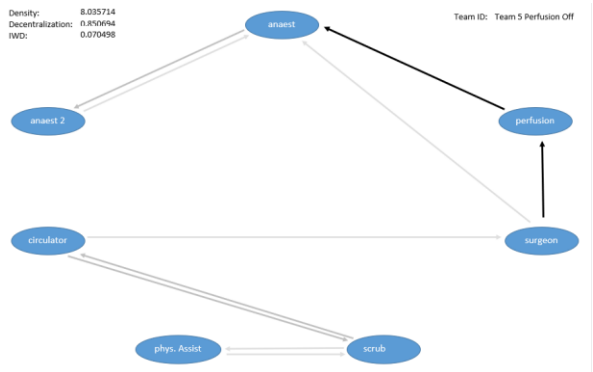
3.Start of perfusion



4. Procedure

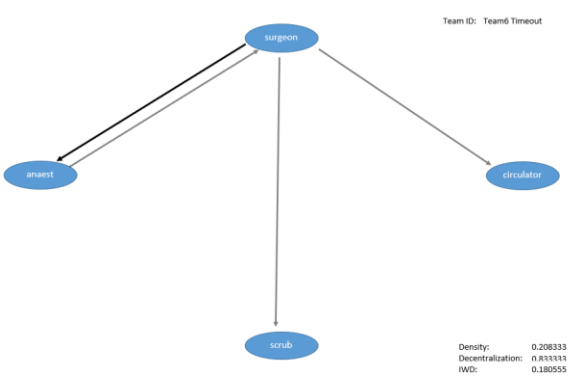


5.End of perfusion

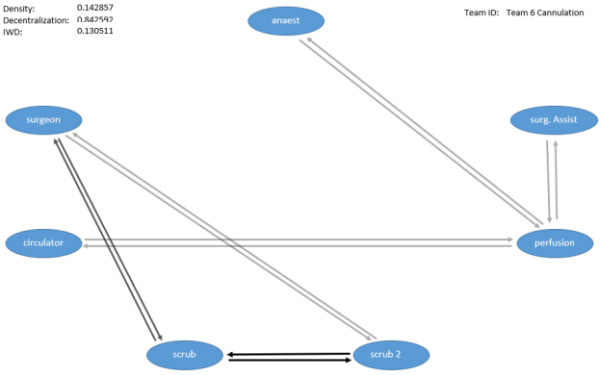


Team 6 (surgeon 4)

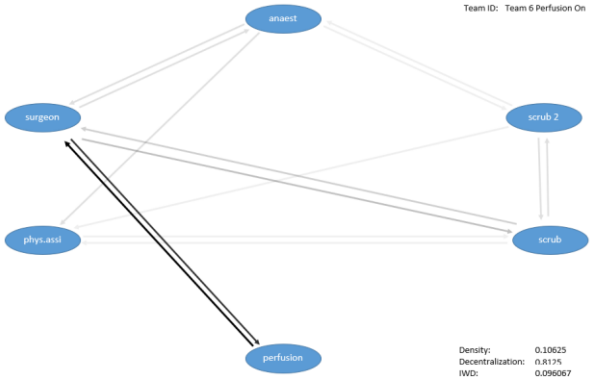
1.Timeout



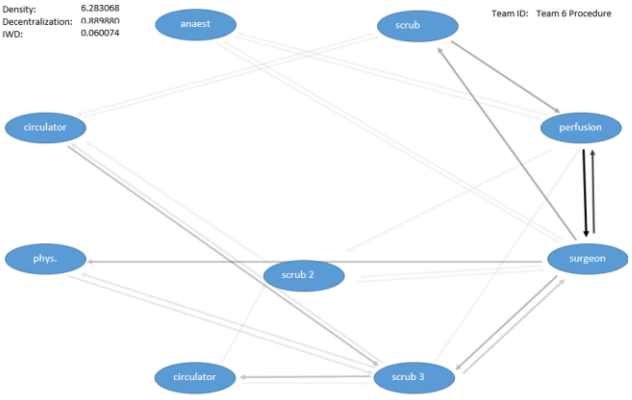
2. Cannulation



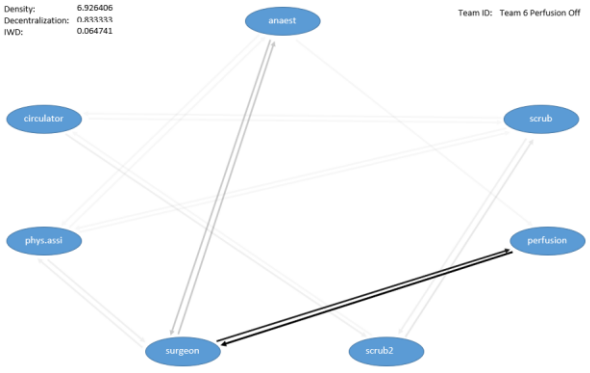
3.Start of perfusion



4. Procedure

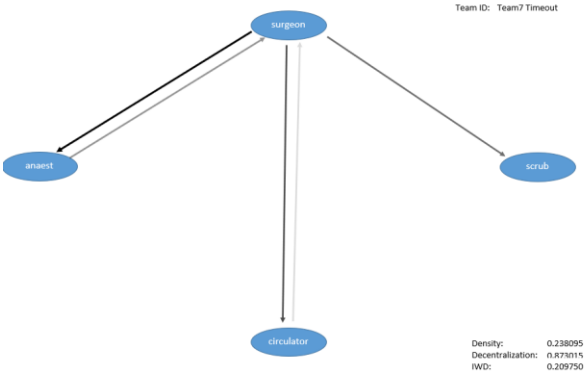


5.End of perfusion

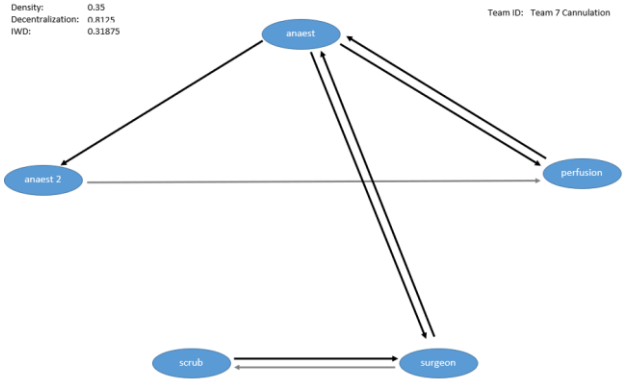


Team 7 (surgeon 5)

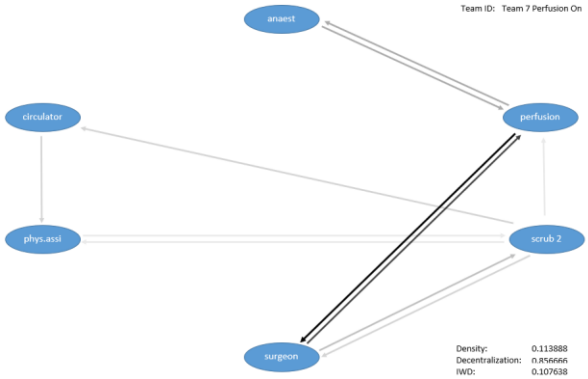
1.Timeout



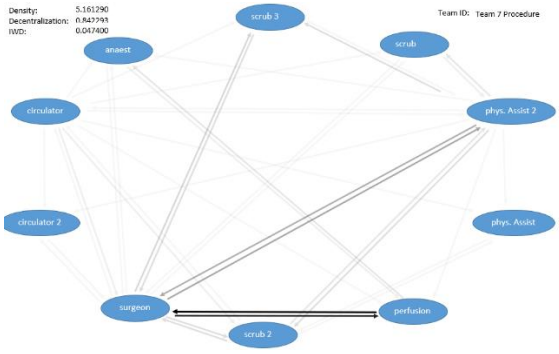
2.Cannulation



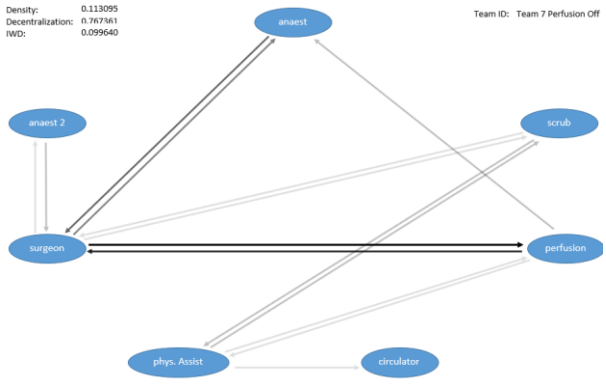
3.Start of perfusion



4. Procedure

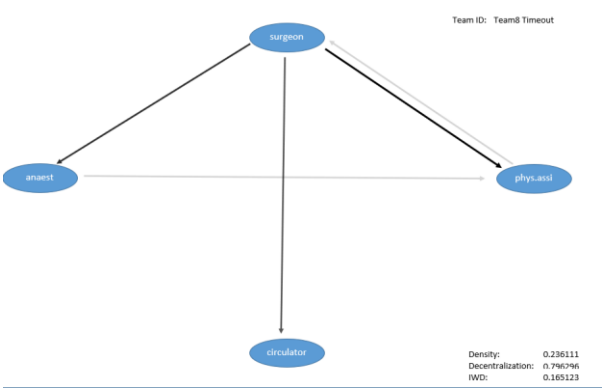


5.End of perfusion

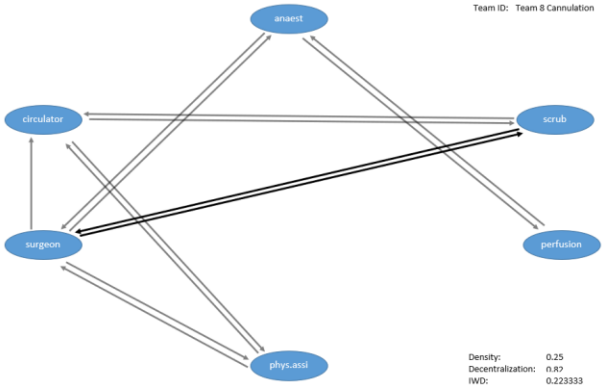


Team 8 (surgeon 5)

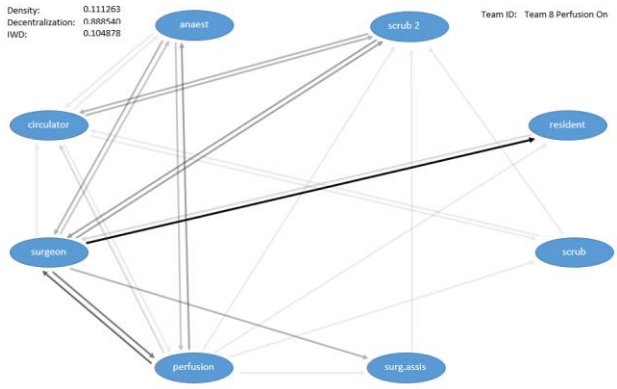
1.Timeout



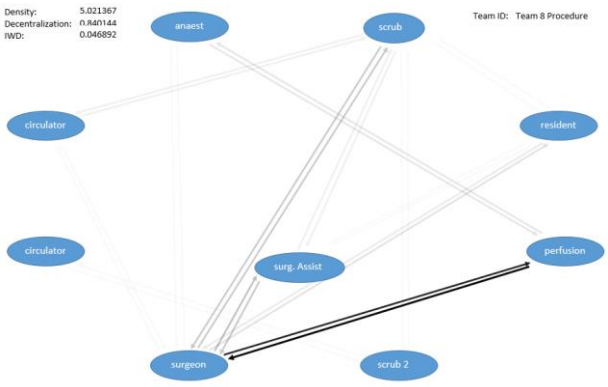
2. Cannulation



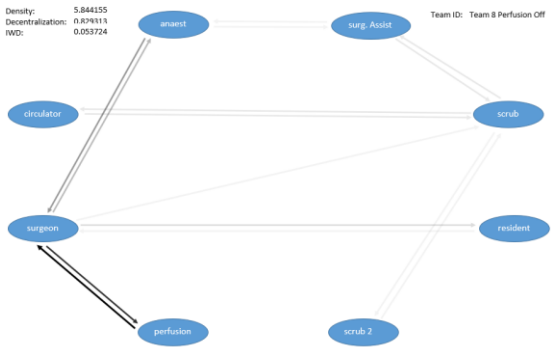
3.Start of perfusion



4. Procedure



5.End of perfusion



Appendix H

Assumption Analysis

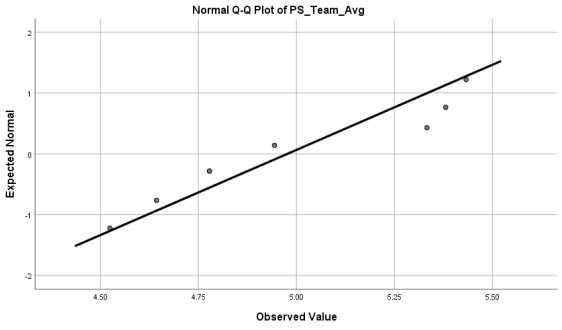
The following table shows the measures for normality of each construct used in the model analysis

Construct	Skewness	Kurtosis	Shapiro-Wilk significance
Psychological Safety	.252	-1.886	.210
Teamwork and Communication	.928	-.620	.074
Performance	.539	1.161	.616
Team's Trust	.126	-1.444	.573
Leadership	1.156	-.032	.075
Surgeon's Perception of Past Performance	.322	-.011	.673
Surgeon's Trust in the Team	.331	2.053	.390

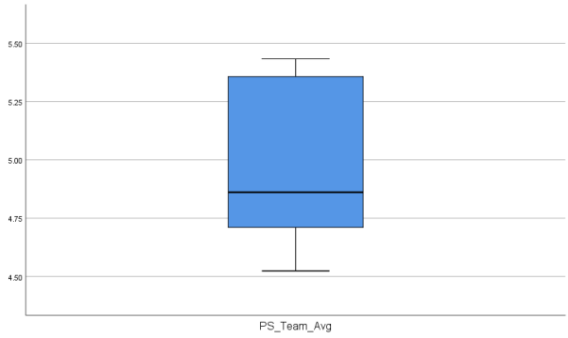
Assumptions of Constructs

Psychological Safety

Normality

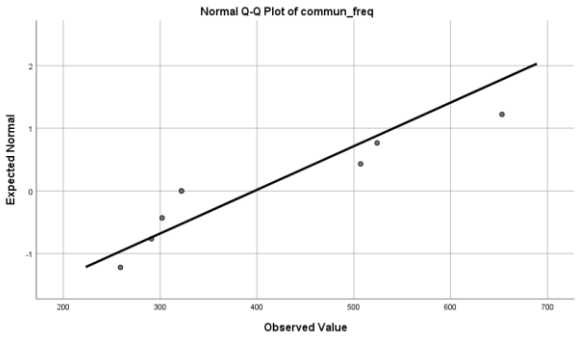


Outliers

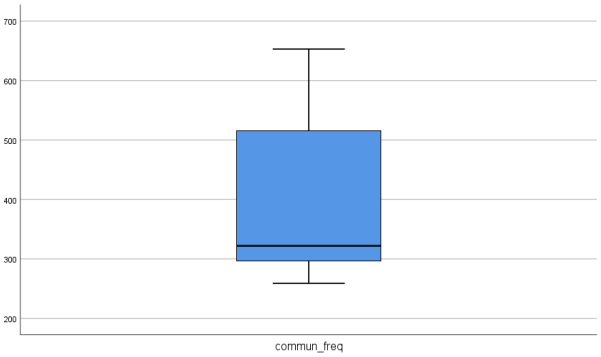


Teamwork and Communication

Normality

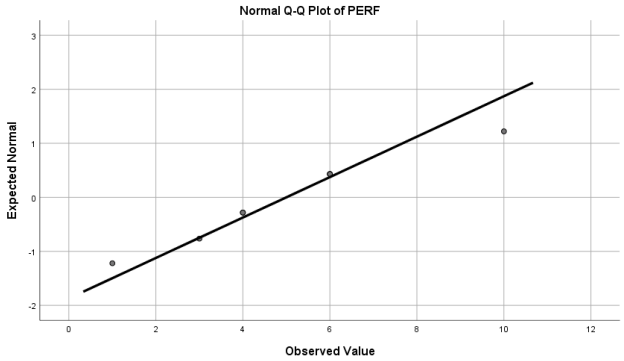


Outliers

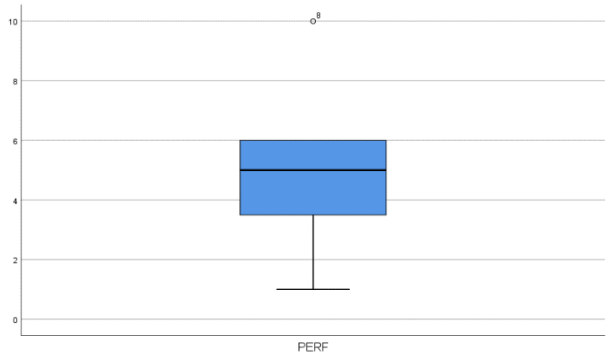


Performance

Normality

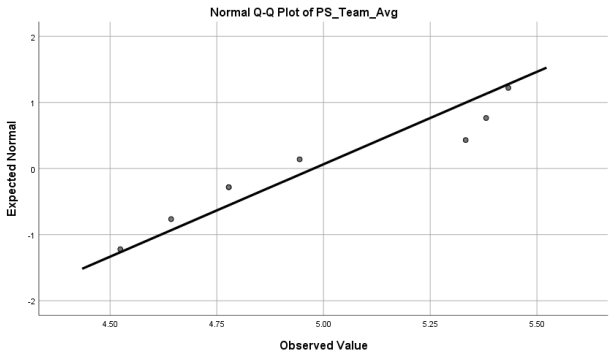


Outliers

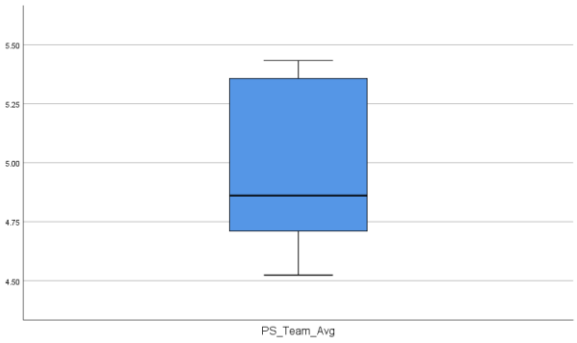


Team's trust

Normality

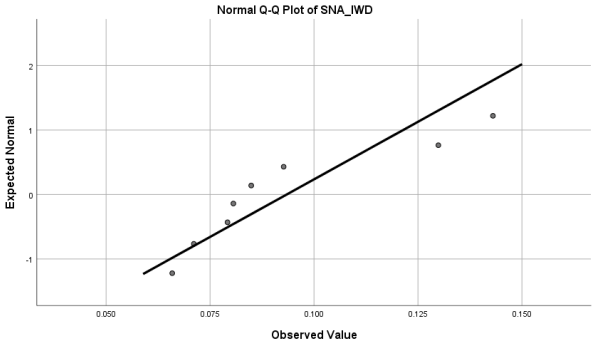


Outliers

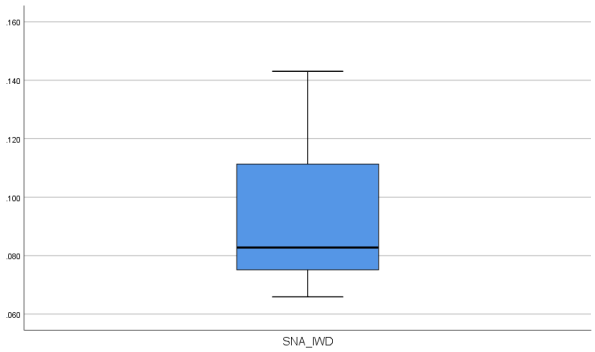


Leadership

Normality

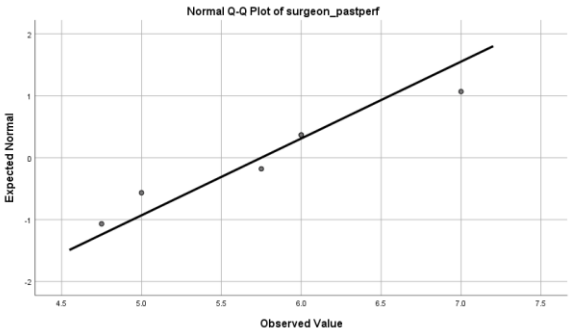


Outliers

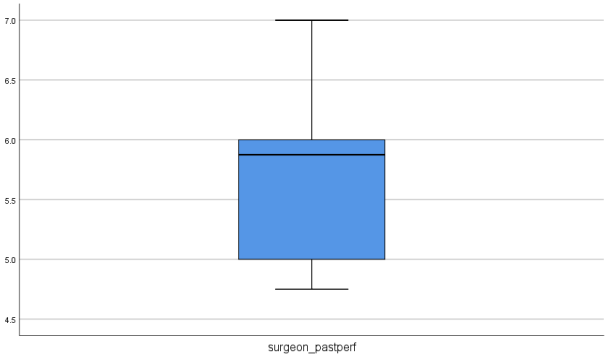


Surgeon's perception of past performance

Normality

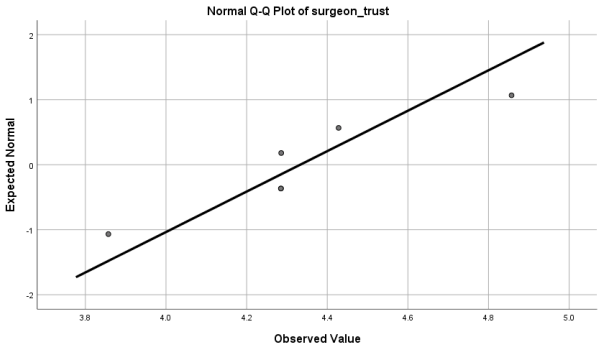


Outliers

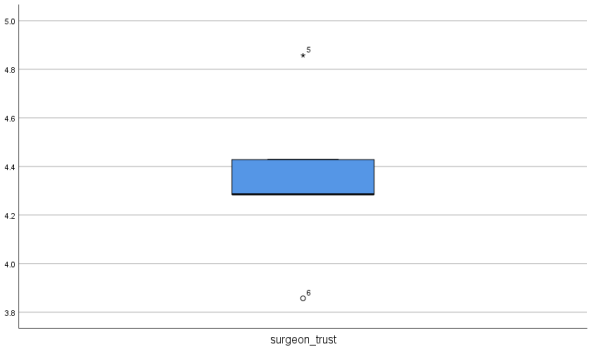


Surgeon's trust in team

Normality



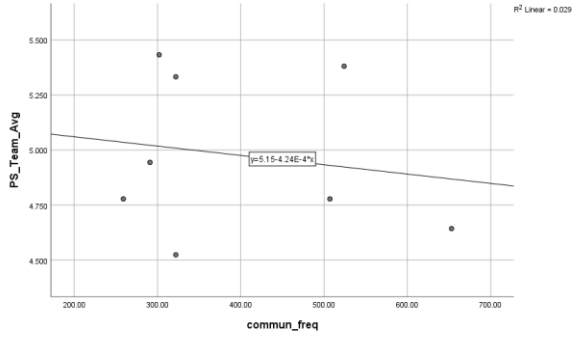
Outliers



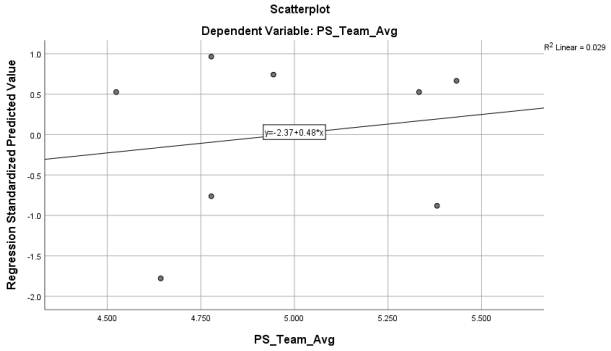
Assumption on Relationships

Psychological Safety and Teamwork and Communication

Linearity

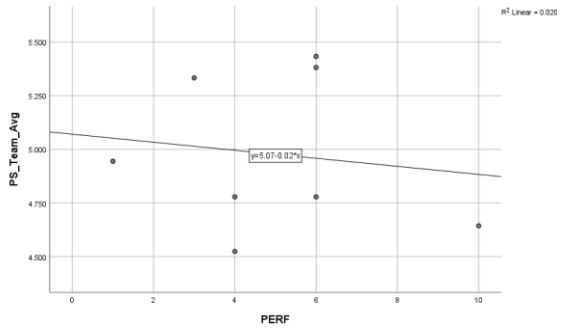


Homoscedasticity



Psychological Safety and Performance

Linearity



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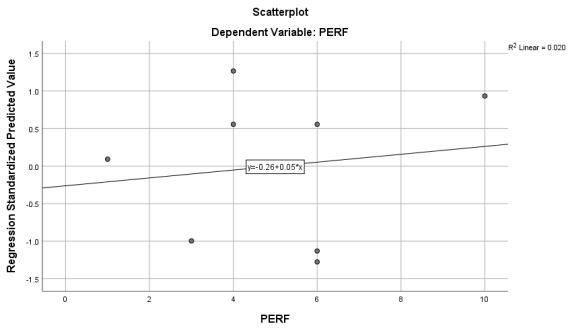
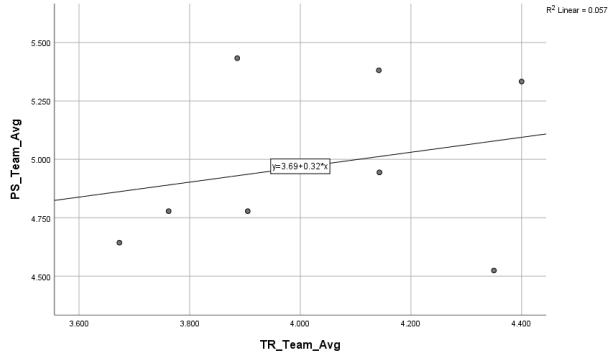


Psychological Safety and Team's Trust

Linearity



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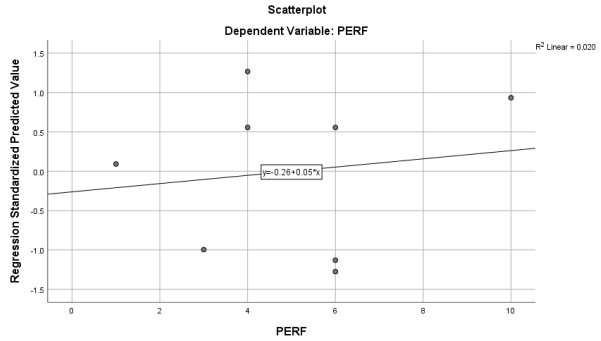
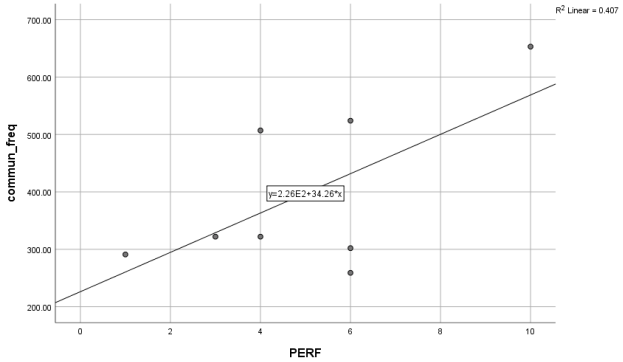


Performance and Teamwork and Communication

Linearity



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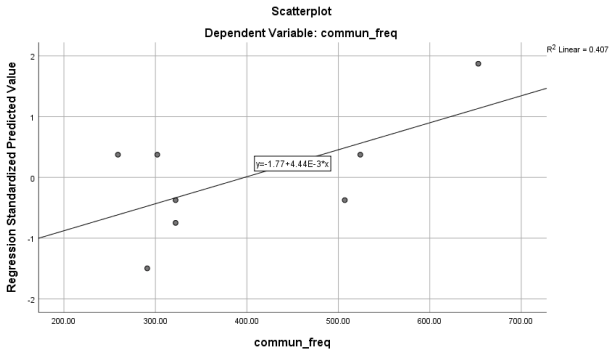
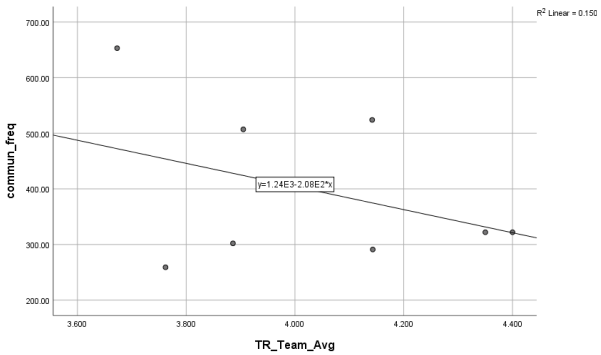


Team's Trust and Teamwork

Linearity



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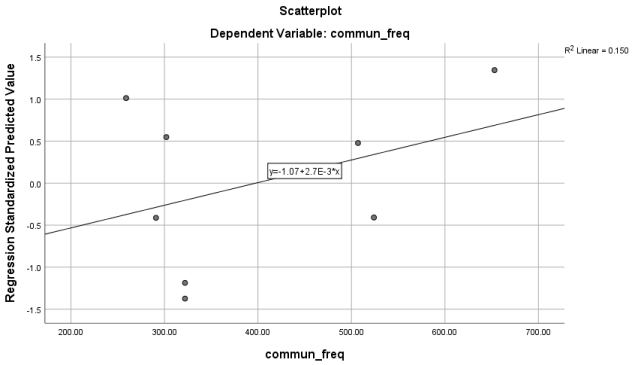
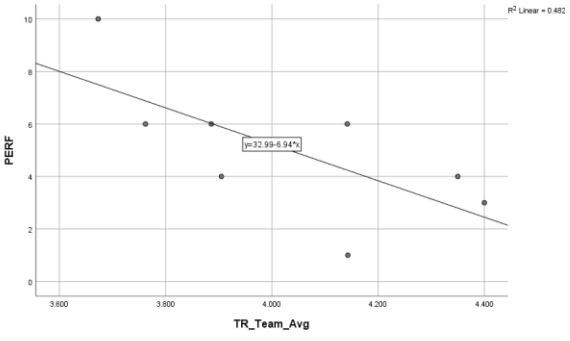


Team's Trust and Performance

Linearity



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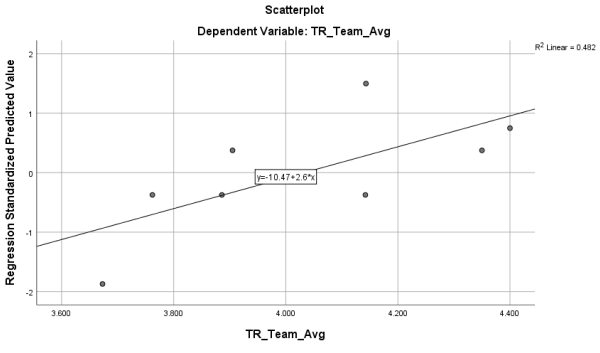
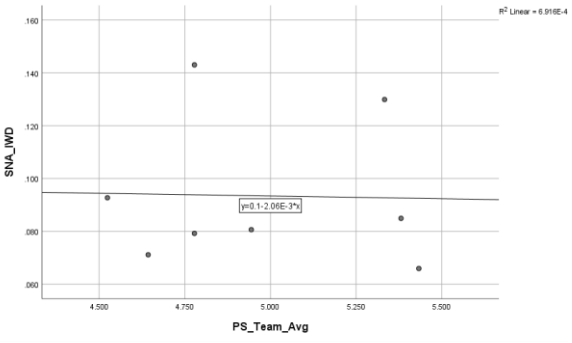


Leadership and Psychological Safety

Linearity



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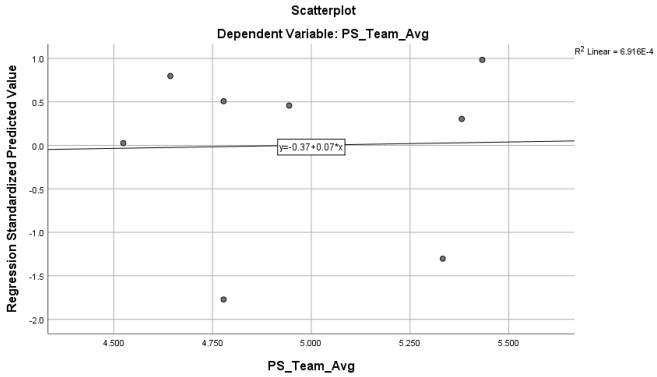
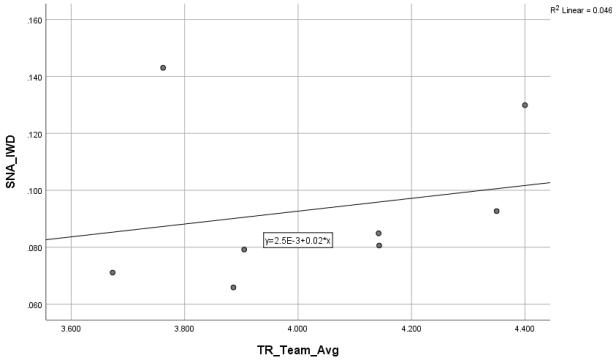


Leadership and Team's Trust

Linearity



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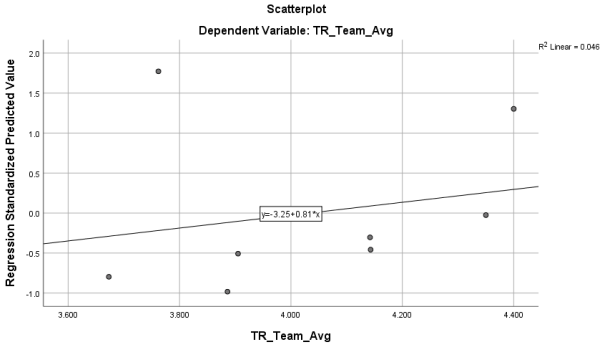
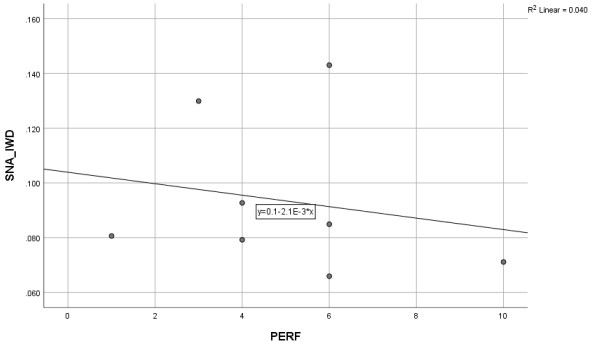
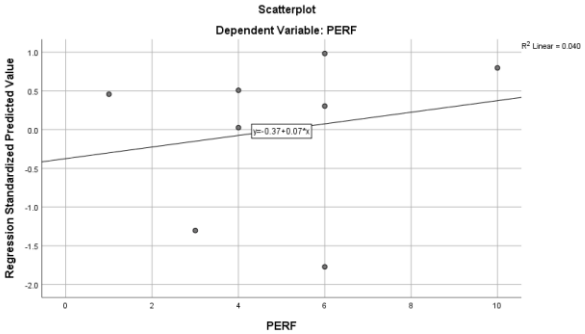


Leadership and Performance

Linearity

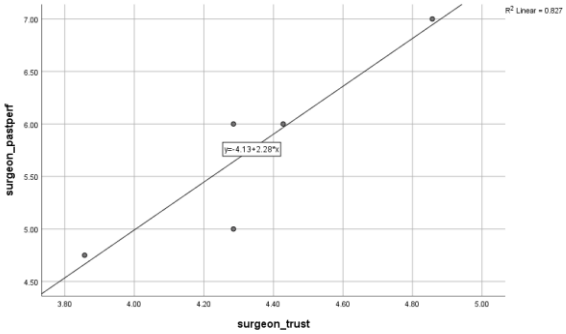


Homoscedasticity



Linearity Surgeon's Perception of Past Performance and Trust the Surgeon has in the Team

Linearity



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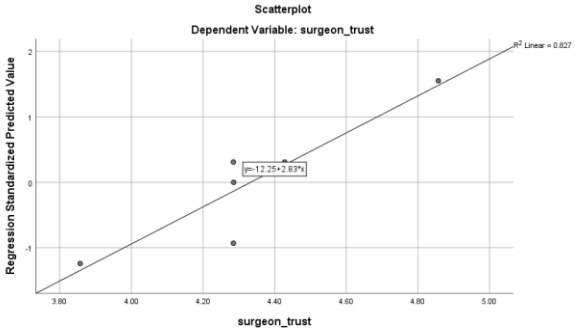
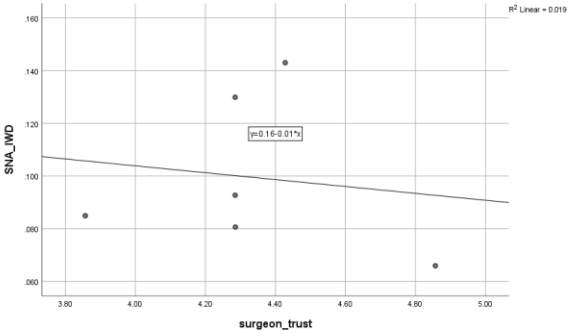


Trust the Surgeon has in his/her Team and Leadership

Linearity



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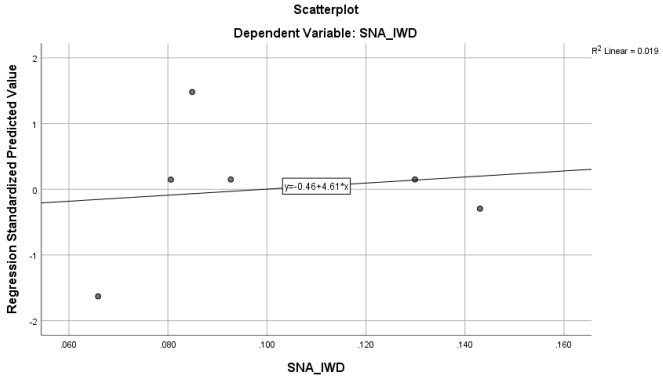

Appendix I

Within Team Correlations for Psychological Safety and Team's Trust

Team 1 (Surgeon 1)

Correlations

Team 1			Psychological Safety						Team's Trust					
			Participant a	Participant b	Participant c	Participant d	Participant e	Participant f	Participant a	Participant b	Participant c	Participant d	Participant e	Participant f
Psychological Safety	Participant a	Pearson Correlation	1											
		Sig. (2-...												
		N	6											
	Participant b	Pearson Correlation	0.501	1										
		Sig. (2-...	0.311											
		N	6	6										
	Participant c	Pearson Correlation	-0.128	-0.558	1									
		Sig. (2-...	0.809	0.250										
		N	6	6	6									
	Participant d	Pearson Correlation	.867*	0.587	-0.511	1								
		Sig. (2-...	0.025	0.220	0.300									
		N	6	6	6	6								
	Participant e	Pearson Correlation	0.648	0.345	0.250	0.437	1							
		Sig. (2-...	0.164	0.504	0.633	0.386								
		N	6	6	6	6	6							
	Participant f	Pearson Correlation	0.532	.978**	-0.439	0.600	0.375	1						
		Sig. (2-...	0.277	0.001	0.384	0.208	0.464							
		N	6	6	6	6	6	6						
Team's Trust	Participant a	Pearson Correlation	0.103	-0.265	0.068	0.066	-0.581	-0.194	1					
		Sig. (2-...	0.846	0.612	0.898	0.901	0.227	0.713						
		N	6	6	6	6	6	6	7					
	Participant b	Pearson Correlation	-0.205	0.285	-0.391	-0.235	-0.540	0.171	0.279	1				
		Sig. (2-...	0.696	0.584	0.443	0.654	0.269	0.745	0.544					
		N	6	6	6	6	6	6	7	7				
	Participant c	Pearson Correlation	0.407	0.060	-0.430	0.420	-0.367	0.000	0.737	0.412	1			
		Sig. (2-...	0.423	0.910	0.395	0.407	0.474	1.000	0.059	0.358				
		N	6	6	6	6	6	6	7	7	7			
	Participant d	Pearson Correlation	-0.184	0.231	-0.487	-0.130	-0.457	0.069	0.280	.861*	0.670	1		
		Sig. (2-...	0.726	0.660	0.328	0.718	0.362	0.896	0.542	0.013	0.100			
		N	6	6	6	6	6	6	7	7	7	7		
	Participant e	Pearson Correlation	0.578	0.125	-0.314	0.438	0.191	0.000	0.258	0.331	0.747	0.588	1	
		Sig. (2-...	0.230	0.814	0.545	0.385	0.716	1.000	0.577	0.469	0.053	0.165		
		N	6	6	6	6	6	6	7	7	7	7	7	
	Participant f	Pearson Correlation	-0.052	0.493	-0.476	-0.066	-0.406	0.387	0.185	.970**	0.338	.785*	0.305	1
		Sig. (2-...	0.923	0.321	0.340	0.901	0.424	0.448	0.692	0.000	0.458	0.036	0.506	
		N	6	6	6	6	6	6	7	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Team 2 (Surgeon 1)

Correlations

Team 2			Psychological Safety							Team's Trust						
			Participant a	Participant b	Participant c	Participant d	Participant e	Participant f	Participant g	Participant a	Participant b	Participant c	Participant d	Participant e	Participant f	Participant g
Psychological Safety	Participant a	Pearson Correlation	1													
		Sig. (2-tailed)														
		N	6													
	Participant b	Pearson Correlation	-0.525	1												
		Sig. (2-tailed)	0.285													
		N	6	6												
	Participant c	Pearson Correlation	-.878*	.812*	1											
		Sig. (2-tailed)	0.021	0.050												
		N	6	6	6											
	Participant d	Pearson Correlation	-0.185	.897*	0.580	1										
		Sig. (2-tailed)	0.726	0.015	0.228											
		N	6	6	6	6										
	Participant e	Pearson Correlation	-0.035	0.295	0.041	0.052	1									
		Sig. (2-tailed)	0.947	0.570	0.939	0.922										
		N	6	6	6	6	6									
	Participant f	Pearson Correlation	-0.500	0.552	0.702	0.369	0.070	1								
		Sig. (2-tailed)	0.312	0.256	0.120	0.471	0.895									
		N	6	6	6	6	6	6								
	Participant g	Pearson Correlation	0.231	-0.102	-0.191	-0.114	0.065	0.463	1							
		Sig. (2-tailed)	0.659	0.847	0.717	0.830	0.902	0.355								
		N	6	6	6	6	6	6	6							
Team's Trust	Participant a	Pearson Correlation	0.325	0.574	0.072	.853*	0.000	0.000	0.000	1						
		Sig. (2-tailed)	0.530	0.234	0.893	0.031	1.000	1.000	1.000							
		N	6	6	6	6	6	6	6	7						
	Participant b	Pearson Correlation	-0.605	0.340	0.491	0.162	0.155	-0.220	-.882*	-0.248	1					
		Sig. (2-tailed)	0.203	0.510	0.323	0.758	0.770	0.675	0.020	0.591						
		N	6	6	6	6	6	6	6	7	7					
	Participant c	Pearson Correlation	-0.373	0.024	0.114	-0.157	0.300	-0.533	-0.730	-0.338	.893**	1				
		Sig. (2-tailed)	0.466	0.965	0.829	0.766	0.563	0.276	0.062	0.458	0.007					
		N	6	6	6	6	6	6	6	7	7	7				
	Participant d	Pearson Correlation	-.866*	0.574	.853*	0.426	-0.366	0.433	-0.267	0.000	0.479	0.180	1			
		Sig. (2-tailed)	0.026	0.234	0.029	0.399	0.476	0.391	0.609	1.000	0.277	0.699				
		N	6	6	6	6	6	6	6	7	7	7	7			
	Participant e	Pearson Correlation	-0.429	0.417	0.411	0.380	0.024	-0.343	-.900*	0.285	.758*	0.697	0.477	1		
		Sig. (2-tailed)	0.396	0.411	0.418	0.457	0.964	0.506	0.015	0.536	0.048	0.082	0.279			
		N	6	6	6	6	6	6	6	7	7	7	7	7		
	Participant f	Pearson Correlation	-0.024	0.042	-0.078	-0.140	0.771	-0.378	-0.525	-0.295	0.633	.757*	-0.303	0.306	1	
		Sig. (2-tailed)	0.965	0.937	0.883	0.792	0.073	0.460	0.285	0.521	0.127	0.049	0.508	0.504		
		N	6	6	6	6	6	6	6	7	7	7	7	7	7	
	Participant g	Pearson Correlation	-0.188	0.552	0.454	0.615	0.070	0.000	-0.772	0.545	0.332	0.216	0.255	.757*	0.132	1
		Sig. (2-tailed)	0.722	0.256	0.365	0.193	0.895	1.000	0.072	0.206	0.384	0.642	0.582	0.049	0.777	
		N	6	6	6	6	6	6	6	7	7	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Team 3 (Surgeon 2)

Correlations

Team 3			Psychological Safety						Team's Trust					
			Participant a	Participant b	Participant c	Participant d	Participant e	Participant f	Participant a	Participant b	Participant c	Participant d	Participant e	Participant f
Psychological Safety	Participant a	Pearson Correlatio	1											
		Sig. (2-tailed)												
		N	6											
	Participant b	Pearson Correlatio	-0.444	1										
		Sig. (2-tailed)	0.378											
		N	6	6										
	Participant c	Pearson Correlatio	0.299	0.417	1									
		Sig. (2-tailed)	0.565	0.411										
		N	6	6	6									
	Participant d	Pearson Correlatio	.972**	-0.549	0.196	1								
		Sig. (2-tailed)	0.001	0.260	0.709									
		N	6	6	6	6								
	Participant e	Pearson Correlatio	0.632	-0.110	0.473	0.664	1							
		Sig. (2-tailed)	0.178	0.836	0.343	0.150								
		N	6	6	6	6	6							
	Participant f	Pearson Correlatio	-0.433	.829*	0.605	-0.455	0.000	1						
		Sig. (2-tailed)	0.391	0.041	0.204	0.365	1.000							
		N	6	6	6	6	6	6						
Team's Trust	Participant a	Pearson Correlatio	0.506	-0.330	-0.473	0.581	0.400	-0.548	1					
		Sig. (2-tailed)	0.306	0.523	0.343	0.226	0.432	0.261						
		N	6	6	6	6	6	6	7					
	Participant b	Pearson Correlatio	0.700	0.000	0.299	0.657	0.158	0.000	0.354	1				
		Sig. (2-tailed)	0.122	1.000	0.565	0.157	0.765	1.000	0.437					
		N	6	6	6	6	6	6	7	7				
	Participant c	Pearson Correlatio	-0.652	0.358	-0.154	-0.495	-0.108	0.594	-0.167	-0.471	1			
		Sig. (2-tailed)	0.161	0.486	0.771	0.318	0.838	0.214	0.721	0.286				
		N	6	6	6	6	6	6	7	7	7			
	Participant d	Pearson Correlatio	0.506	-0.330	-0.473	0.581	0.400	-0.548	.881**	0.113	0.040	1		
		Sig. (2-tailed)	0.306	0.523	0.343	0.226	0.432	0.261	0.009	0.809	0.932			
		N	6	6	6	6	6	6	7	7	7	7		
	Participant e	Pearson Correlatio	0.278	-0.081	-0.323	0.365	0.586	-0.267	.801*	-0.113	0.240	.885**	1	
		Sig. (2-tailed)	0.594	0.879	0.532	0.477	0.222	0.609	0.031	0.809	0.604	0.008		
		N	6	6	6	6	6	6	7	7	7	7	7	
	Participant f	Pearson Correlatio	0.283	-0.492	0.212	0.186	-0.149	-0.408	-0.354	0.167	-.766*	-0.510	-0.679	1
		Sig. (2-tailed)	0.587	0.321	0.687	0.725	0.778	0.422	0.437	0.721	0.045	0.243	0.093	
		N	6	6	6	6	6	6	7	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Team 4 (Surgeon 2)

Correlations

Team 4			Psychological Safety					Team's Trust				
			Participant a	Participant b	Participant c	Participant d	Participant e	Participant a	Participant b	Participant c	Participant d	Participant e
Psychological Safety	Participant a	Pearson Correlation	1									
		Sig. (2-tailed)										
		N	6									
	Participant b	Pearson Correlation	-0.259	1								
		Sig. (2-tailed)	0.620									
		N	6	6								
	Participant c	Pearson Correlation	-0.082	.962**	1							
		Sig. (2-tailed)	0.877	0.002								
		N	6	6	6							
	Participant d	Pearson Correlation	0.530	0.573	0.626	1						
		Sig. (2-tailed)	0.280	0.235	0.184							
		N	6	6	6	6						
	Participant e	Pearson Correlation	0.078	0.475	0.662	0.261	1					
		Sig. (2-tailed)	0.883	0.341	0.152	0.618						
		N	6	6	6	6	6					
Team's Trust	Participant a	Pearson Correlation	-0.293	0.399	0.447	0.047	0.756	1				
		Sig. (2-tailed)	0.573	0.433	0.374	0.930	0.082					
		N	6	6	6	6	6	7				
	Participant b	Pearson Correlation	-0.721	0.505	0.427	-0.089	0.459	.847*	1			
		Sig. (2-tailed)	0.106	0.307	0.398	0.867	0.360	0.016				
		N	6	6	6	6	6	7	7			
	Participant c	Pearson Correlation	-0.476	0.430	0.447	0.093	0.625	.801*	.882**	1		
		Sig. (2-tailed)	0.340	0.395	0.374	0.861	0.185	0.031	0.009			
		N	6	6	6	6	6	7	7	7		
	Participant d	Pearson Correlation	-0.579	0.233	0.268	-0.205	0.559	0.366	0.543	0.703	1	
		Sig. (2-tailed)	0.229	0.656	0.607	0.697	0.249	0.419	0.208	0.078		
		N	6	6	6	6	6	7	7	7	7	
	Participant e	Pearson Correlation	-0.529	0.543	0.532	0.159	0.576	.758*	.894**	.986**	0.659	1
		Sig. (2-tailed)	0.280	0.265	0.277	0.764	0.232	0.048	0.007	0.000	0.107	
		N	6	6	6	6	6	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Team 5 (Surgeon 3)

Correlations

Team 5			Psychological Safety					Team's Trust				
			Participant a	Participant b	Participant c	Participant d	Participant e	Participant a	Participant b	Participant c	Participant d	Participant e
Psychological Safety	Participant a	Pearson Correlation	1									
		Sig. (2-tailed)										
		N	6									
	Participant b	Pearson Correlation	-0.472	1								
		Sig. (2-tailed)	0.345									
		N	6	6								
	Participant c	Pearson Correlation	-0.557	.937**	1							
		Sig. (2-tailed)	0.251	0.006								
		N	6	6	6							
	Participant d	Pearson Correlation	-0.558	.946**	.981**	1						
		Sig. (2-tailed)	0.250	0.004	0.001							
		N	6	6	6	6						
	Participant e	Pearson Correlation	-0.571	.866*	0.769	.867*	1					
		Sig. (2-tailed)	0.237	0.026	0.074	0.025						
		N	6	6	6	6	6					
Team's Trust	Participant a	Pearson Correlation	-0.242	0.531	0.647	0.610	0.339	1				
		Sig. (2-tailed)	0.644	0.278	0.164	0.198	0.512					
		N	6	6	6	6	6	7				
	Participant b	Pearson Correlation	-0.514	0.325	0.141	0.166	0.430	-0.498	1			
		Sig. (2-tailed)	0.297	0.529	0.790	0.753	0.395	0.255				
		N	6	6	6	6	6	7	7			
	Participant c	Pearson Correlation	-0.539	0.291	0.109	0.155	0.457	-0.373	.956**	1		
		Sig. (2-tailed)	0.269	0.575	0.837	0.770	0.362	0.410	0.001			
		N	6	6	6	6	6	7	7	7		
	Participant d	Pearson Correlation	-0.579	-0.053	-0.155	-0.122	0.180	-0.366	.801*	.902**	1	
		Sig. (2-tailed)	0.229	0.921	0.770	0.819	0.733	0.419	0.031	0.006		
		N	6	6	6	6	6	7	7	7	7	
	Participant e	Pearson Correlation	-0.399	0.754	0.543	0.623	.846*	0.070	0.673	.755*	0.477	1
		Sig. (2-tailed)	0.434	0.083	0.266	0.187	0.034	0.882	0.097	0.050	0.279	
		N	6	6	6	6	6	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Team 6 (Surgeon 4)

Correlations

Team 6			Psychological Safety							Team's Trust						
			Participant a	Participant b	Participant c	Participant d	Participant e	Participant f	Participant g	Participant a	Participant b	Participant c	Participant d	Participant e	Participant f	Participant g
Psychological Safety	Participant a	Pearson Correlation	1													
		Sig. (2-tailed)														
		N	6													
	Participant b	Pearson Correlation	-0.014	1												
		Sig. (2-tailed)	0.979													
		N	6	6												
	Participant c	Pearson Correlation	0.622	0.282	1											
		Sig. (2-tailed)	0.188	0.588												
		N	6	6	6											
	Participant d	Pearson Correlation	0.105	-.860*	0.131	1										
		Sig. (2-tailed)	0.843	0.028	0.805											
		N	6	6	6	6										
	Participant e	Pearson Correlation	0.302	.927**	0.375	-0.808	1									
		Sig. (2-tailed)	0.561	0.008	0.464	0.052										
		N	6	6	6	6	6									
	Participant f	Pearson Correlation	0.000	.993**	0.302	-.866*	.933**	1								
		Sig. (2-tailed)	1.000	0.000	0.561	0.026	0.007									
		N	6	6	6	6	6	6								
	Participant g	Pearson Correlation	0.000	.993**	0.302	-.866*	.933**	1.000**	1							
		Sig. (2-tailed)	1.000	0.000	0.561	0.026	0.007	0.000								
		N	6	6	6	6	6	6	6							
Team's Trust	Participant a	Pearson Correlation	0.129	-0.118	-0.543	-0.367	-0.033	-0.106	-0.106	1						
		Sig. (2-tailed)	0.808	0.824	0.265	0.474	0.951	0.842	0.842							
		N	6	6	6	6	6	6	6	7						
	Participant b	Pearson Correlation	-0.434	0.444	0.135	-0.387	0.139	0.447	0.447	0.000	1					
		Sig. (2-tailed)	0.390	0.378	0.799	0.448	0.793	0.374	0.374	1.000						
		N	6	6	6	6	6	6	6	7	7					
	Participant c	Pearson Correlation	-0.127	0.519	-0.157	-0.754	0.379	0.522	0.522	0.627	0.710	1				
		Sig. (2-tailed)	0.811	0.292	0.766	0.083	0.459	0.288	0.288	0.131	0.074					
		N	6	6	6	6	6	6	6	7	7	7				
	Participant d	Pearson Correlation	0.315	0.597	0.448	-0.482	0.520	0.557	0.557	0.113	0.560	0.651	1			
		Sig. (2-tailed)	0.543	0.211	0.373	0.332	0.290	0.251	0.251	0.809	0.191	0.113				
		N	6	6	6	6	6	6	6	7	7	7	7			
	Participant e	Pearson Correlation	.814*	-0.282	0.500	0.332	0.000	-0.302	-0.302	0.032	-0.510	-0.285	0.214	1		
		Sig. (2-tailed)	0.011	0.588	0.312	0.443	1.000	0.561	0.561	0.845	0.243	0.536	0.645			
		N	6	6	6	6	6	6	6	7	7	7	7	7		
	Participant f	Pearson Correlation	-0.347	0.141	0.364	0.065	-0.141	0.151	0.151	-0.405	.806*	0.258	0.397	-0.377	1	
		Sig. (2-tailed)	0.500	0.790	0.479	0.902	0.790	0.776	0.776	0.367	0.029	0.576	0.378	0.404		
		N	6	6	6	6	6	6	6	7	7	7	7	7	7	
	Participant g	Pearson Correlation	-0.019	0.437	0.380	-0.273	0.221	0.394	0.394	0.000	.816*	0.632	.857*	0.000	0.646	1
		Sig. (2-tailed)	0.971	0.386	0.457	0.601	0.674	0.440	0.440	1.000	0.025	0.127	0.014	1.000	0.117	
		N	6	6	6	6	6	6	6	7	7	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Team 7 (Surgeon 5)

Correlations

Team 7			Psychological Safety						Team's Trust					
			Participant a	Participant b	Participant c	Participant d	Participant e	Participant f	Participant a	Participant b	Participant c	Participant d	Participant e	Participant f
Psychological Safety	Participant a	Pearson Correlation	1											
		Sig. (2-tailed)												
		N	6											
	Participant b	Pearson Correlation	0.757	1										
		Sig. (2-tailed)	0.081											
		N	6	6										
	Participant c	Pearson Correlation	0.500	0.083	1									
		Sig. (2-tailed)	0.313	0.875										
		N	6	6	6									
	Participant d	Pearson Correlation	-.935**	-0.712	-0.453	1								
		Sig. (2-tailed)	0.006	0.113	0.367									
		N	6	6	6	6								
	Participant e	Pearson Correlation	.852*	0.726	0.674	-0.710	1							
		Sig. (2-tailed)	0.031	0.102	0.142	0.114								
		N	6	6	6	6	6							
	Participant f	Pearson Correlation	-0.083	0.110	0.472	0.075	0.390	1						
		Sig. (2-tailed)	0.876	0.835	0.344	0.888	0.445							
		N	6	6	6	6	6	6						
Team's Trust	Participant a	Pearson Correlation	0.395	0.273	-0.203	-0.540	-0.114	-0.753	1					
		Sig. (2-tailed)	0.438	0.601	0.699	0.269	0.830	0.084						
		N	6	6	6	6	6	6	7					
	Participant b	Pearson Correlation	0.442	0.368	-0.365	-0.381	0.010	-.877*	.789*	1				
		Sig. (2-tailed)	0.380	0.473	0.477	0.456	0.985	0.022	0.035					
		N	6	6	6	6	6	6	7	7				
	Participant c	Pearson Correlation	0.702	0.221	0.661	-0.750	0.446	-0.250	0.611	0.420	1			
		Sig. (2-tailed)	0.120	0.674	0.153	0.086	0.376	0.633	0.145	0.349				
		N	6	6	6	6	6	6	7	7	7			
	Participant d	Pearson Correlation	0.070	-0.518	0.322	0.032	0.024	-0.213	-0.059	0.198	0.307	1		
		Sig. (2-tailed)	0.894	0.293	0.533	0.952	0.964	0.685	0.901	0.670	0.503			
		N	6	6	6	6	6	6	7	7	7	7		
	Participant e	Pearson Correlation	0.456	0.415	-0.167	-0.662	-0.012	-0.552	.902**	0.528	0.499	-0.322	1	
		Sig. (2-tailed)	0.363	0.414	0.752	0.152	0.982	0.256	0.006	0.224	0.254	0.481		
		N	6	6	6	6	6	6	7	7	7	7	7	
	Participant f	Pearson Correlation	-0.702	-0.552	-0.661	0.525	-.947**	-0.500	0.418	0.354	-0.091	0.070	0.187	1
		Sig. (2-tailed)	0.120	0.256	0.153	0.285	0.004	0.312	0.350	0.437	0.846	0.881	0.689	
		N	6	6	6	6	6	6	7	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Team 8 (Surgeon 5)

Correlations

Team 8			Psychological Safety							Team's Trust						
			Participant a	Participant b	Participant c	Participant d	Participant e	Participant f	Participant g	Participant a	Participant b	Participant c	Participant d	Participant e	Participant f	Participant g
Psychological Safety	Participant a	Pearson Correlation	1													
		Sig. (2-tailed)														
		N	6													
	Participant b	Pearson Correlation	-0.372	1												
		Sig. (2-tailed)	0.468													
		N	6	6												
	Participant c	Pearson Correlation	0.152	-.816*	1											
		Sig. (2-tailed)	0.774	0.047												
		N	6	6	6											
	Participant d	Pearson Correlation	.877*	-0.707	0.433	1										
		Sig. (2-tailed)	0.022	0.116	0.391											
		N	6	6	6	6										
	Participant e	Pearson Correlation	0.037	-0.603	0.554	0.107	1									
		Sig. (2-tailed)	0.944	0.205	0.254	0.841										
		N	6	6	6	6	6									
	Participant f	Pearson Correlation	.877*	-0.707	0.433	1.000**	0.107	1								
		Sig. (2-tailed)	0.022	0.116	0.391	0.000	0.841									
		N	6	6	6	6	6	6								
	Participant g	Pearson Correlation	0.411	0.302	0.000	0.213	-0.591	0.213	1							
		Sig. (2-tailed)	0.418	0.561	1.000	0.685	0.217	0.685								
		N	6	6	6	6	6	6	6							
Team's Trust	Participant a	Pearson Correlation	-0.583	0.174	0.000	-0.369	-0.315	-0.369	-0.157	1						
		Sig. (2-tailed)	0.225	0.742	1.000	0.471	0.543	0.471	0.766							
		N	6	6	6	6	6	6	6	7						
	Participant b	Pearson Correlation	-0.150	-0.243	0.237	-0.171	0.804	-0.171	-0.585	0.194	1					
		Sig. (2-tailed)	0.776	0.643	0.568	0.745	0.054	0.745	0.223	0.677						
		N	6	6	6	6	6	6	6	7	7					
	Participant c	Pearson Correlation	0.081	-0.655	0.802	0.463	0.000	0.463	0.197	0.279	-0.240	1				
		Sig. (2-tailed)	0.878	0.158	0.055	0.355	1.000	0.355	0.708	0.544	0.604					
		N	6	6	6	6	6	6	6	7	7	7				
	Participant d	Pearson Correlation	-0.055	-0.447	0.548	0.316	-0.270	0.316	0.270	0.258	-0.417	.801*	1			
		Sig. (2-tailed)	0.917	0.374	0.261	0.541	0.605	0.541	0.605	0.576	0.352	0.031				
		N	6	6	6	6	6	6	6	7	7	7	7			
	Participant e	Pearson Correlation	-0.215	-0.577	0.707	0.000	0.783	0.000	-0.522	0.354	.867*	0.175	0.091	1		
		Sig. (2-tailed)	0.683	0.230	0.116	1.000	0.065	1.000	0.288	0.437	0.011	0.707	0.846			
		N	6	6	6	6	6	6	6	7	7	7	7	7		
	Participant f	Pearson Correlation	-0.351	0.000	0.433	-0.250	-0.107	-0.250	0.426	-0.091	-0.471	0.510	0.471	-0.258	1	
		Sig. (2-tailed)	0.495	1.000	0.391	0.633	0.841	0.633	0.339	0.846	0.286	0.243	0.286	0.576		
		N	6	6	6	6	6	6	6	7	7	7	7	7	7	
	Participant g	Pearson Correlation	0.124	-0.667	0.612	0.354	0.603	0.354	-0.452	0.388	.766*	0.311	0.059	.871*	-0.458	1
		Sig. (2-tailed)	0.815	0.148	0.196	0.492	0.205	0.492	0.368	0.390	0.045	0.497	0.900	0.011	0.301	
		N	6	6	6	6	6	6	6	7	7	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).