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THE ROLE OF TEAMWORK IN DIAGNOSIS: TEAM DIAGNOSTIC
DECISION-MAKING IN THE MEDICAL INTENSIVE CARE UNIT

by
Brennan S. Ayres

A thesis submitted in partial fulfillment
of the requirements for the
Master of Science degree in Industrial Engineering
in the Graduate College of
The University of Iowa

August 2017

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

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To my sister, Jennifer Christine Ayres.

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ABSTRACT

Diagnostic errors cause significant patient harm and occur among 15 percent of all clinical diagnoses, but research has yet to effectively target, prevent, and mitigate diagnostic errors from occurring. So far, literature has examined how diagnostician decision-makers perform and reach a clinical diagnosis individually. However, the impact of team-based activities on diagnosis is unknown. The purpose of this study is to describe provider perception on how providers come together as a team in order to complete a clinical diagnosis. As a qualitative descriptive study with overtones of grounded theory, 18 semi-structured interviews of medical intensive care unit providers were audio-recorded, transcribed, and coded, generating themes of diagnostic teamwork structure and functioning. Diagnostic teams are described as using both inter-professional and intra-professional teamwork among roles, with and without diagnostic team identity. Novel approaches to diagnostic error research, practice implications for current providers, and applications provided for improving education and team training. By providing preliminary insights on the role of teamwork in diagnostic decision-making, this study may assist future studies that improve diagnostic teamwork and prevent diagnostic errors.

PUBLIC ABSTRACT

Healthcare workers, such as physicians, strive to do no harm; however, preventable medical errors can occur when physician decision-making fails while diagnosing patients. Diagnostic errors, in the form of missed diagnosis, or incorrectly derived diagnosis may result in patient harm or even in death. To study how diagnostic errors occur, and how they may be prevented, researchers primarily have studied the decision-making of individual physicians in order to understand how diagnostic decision-making may fail. Several error reduction methods have been derived, however, it remains unknown how effectively to reduce diagnostic error occurrence. Further, diagnosticians do not work alone to diagnose patients: they work with other providers as a team, and such teamwork neither has been studied regarding diagnostic decision-making, nor diagnostic error. This study, therefore, seeks to understand how healthcare providers work together as a team in order to diagnose a patient. In this study, medical intensive care unit providers are interviewed regarding whom they worked with, whom they perceived as a part of the diagnostic team, when they worked with others, and how varying patient presentations changed their teamwork. Provider perceptions were determined through these interviews, and used to describe how diagnostic teams are structured and how they function. Results are presented and suggestions are made for discussion topics of diagnostic contributions from roles such as nurses and patients. Finally, in this study, are proposed new research questions and methods to assist future studies that examine new sources of diagnostic error, and considerations of error reduction methods are offered.

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CHAPTER 1

LITERATURE REVIEW

Diagnostic errors cause significant patient harm and occur in approximately 15 percent of diagnoses, but we have limited knowledge on how to more effectively target, prevent, and mitigate diagnostic errors from occurring. Research has examined how diagnostician decision-makers perform and reach a clinical diagnosis individually. However, the impact of others' contributions in the team-based activity of diagnosis has not been studied. The influence of teamwork in diagnosis and diagnostic errors is not clearly known. In the I.O.M. report on diagnostic errors, the committee concluded the role of teamwork involved in diagnosis is unclear (Balogh, Miller, and Ball 2016). In particular, major gaps exist in understanding when and how inter-professional and intra-professional collaboration occurs during the diagnostic process, especially for clinical decision-making portions. This thesis investigates diagnostic team structure and functioning among medical ICU providers by obtaining perceptions about diagnostic teamwork. In order to understand the motivation and gaps, a literature review follows to describe diagnostic errors, the decision-making process of clinical diagnosis, and teamwork decision-making.

1.1 Diagnostic Errors

Diagnostic error, a major source of preventable errors, poses a crucial public health challenge (Newman-Toker and Pronovost 2009). Diagnostic errors are defined as incorrect, delayed, or missed diagnoses, and usually are detected by retrospective evaluation. Diagnostic errors include inadequately communicated diagnoses to the patient (Balogh, Miller, and Ball 2016). Errors can occur anywhere in the diagnostic process (Winters et al. 2012): when patients initially engage with healthcare workers, when healthcare workers engage in information gathering, during information integration and interpretation, during establishment of an explanatory diagnosis, and in communication to the patient (Balogh, Miller, and Ball 2016).

Diagnostic errors occur because performing a diagnosis is considered extremely difficult due to limited time and information, uncertain conditions, inadequate experience and expertise for a presented symptom or disease, and lack of feedback due to ineffective patient follow-up (Newman-Toker and Makary 2013).

The true rate of diagnostic errors in medicine remains unknown, but estimates of diagnostic errors differ among specialties. Data from autopsies, patient and provider surveys, standardized patients, second reviews, diagnostic testing audits, malpractice claims, case reviews, and voluntary reports indicate 5-20% of diagnoses involve some amount of preventable error (Norman and Eva 2010, Graber 2005, Graber 2013). Diagnostic errors occur in every specialty (Berner and Graber 2008). Three primary areas at risk include emergency care, primary care, and intensive care. Perceptual specialties such as radiology and pathology present lower risks compared to other specialties such as emergency and primary care (Berner and Graber 2008). A recent report by the Institute of Medicine reports approximately 5% of outpatients, (i.e., about 1 in 20 of the US adult population) in the United States have or will experience a diagnostic error (Graber 2005, Balogh, Miller, and Ball 2016, Porche 2016). Autopsy studies show 10% to 20% of patients die due to undiagnosed diseases (Shojania et al. 2003), indicating diagnostic errors may cause 80,000 patient deaths per year among ambulatory and inpatient settings in the U.S (Leape 2002). Postmortem research has found diagnostic errors to account for approximately 10% of patient deaths (Balogh, Miller, and Ball 2016).

Diagnostic errors have received much less focus compared to treatment errors such as medication errors (Thammasitboon, Thammasitboon, and Singhal 2013, Wachter 2010), despite contributing to 17% of hospital adverse events and 20% of all medical errors (Leape et al. 1991). Diagnostic errors have received less focus because such errors are subtle to detect, infrequently reported, and considered difficult to resolve. Diagnostic errors currently represent the most common, costly, and dangerous of medical mistakes settled in malpractice suits (Saber Tehrani et al. 2013).

Most diagnostic errors do not occur for rare diseases or disorders. Diagnostic errors more frequently occur in atypical presentation of a common disease or disorder in familiar settings (2014, Singh et al. 2013). In a study of primary care, the most missed diagnoses consisted of common conditions: pneumonia, heart failure, renal failure, primary cancer, urinary tract infections, and pyelonephritis (Singh et al. 2013). The number of possible diagnostic choices also contributes to the complexity in effective diagnosis with over 12,420 diseases, 5,000 tests, and 250 common chief complaints (2017).

The understanding of diagnostic errors has expanded in the last fifteen years. Research suggests diagnostic errors occur from combinations of contributing factors, with cognitive factors playing a predominant role. Cognitive errors can occur at any step during the diagnostic process (Kassirer and Kopelman 1989). Research on cognitive errors in diagnoses primarily has focused on the individual decision-maker who performs the diagnosis. Cognitive error for diagnosis manifests among four types: omission, premature conclusions, inadequate synthesis, and wrong formulation (Voytovich, Rippey, and Suffredini 1985). Omission and inadequate synthesis negatively correlate with training and lead to false negatives, while premature conclusions occur independent of experience but correlate with overconfidence and lead to false positive diagnoses (Voytovich, Rippey, and Suffredini 1985).

What remains unknown, are the true extent of incidence and harm from diagnostic errors and a comprehensive understanding of why diagnostic errors occur. Additionally, empirical evidence for cognitive errors as a contributor to diagnostic errors is limited (van den Berge and Mamede 2013). The effectiveness of counter measures to prevent diagnostic errors such as debiasing is necessary to investigate. Most importantly, it is not known how teams contribute to the diagnosis, and how we effectively can tap into the teamwork aspect of diagnosis to reduce diagnostic errors in the future.

Examining the diagnostic decision-making process can provide insights to better understand how a diagnosis is made, and identify potential points for errors. The following sections will discuss the diagnostic process, and relevant models and concepts on diagnostic

decision-making of the individual and teams. Section 1.1 provides a brief summary of diagnostic errors while Section 1.2 defines the medical diagnostic task and how diagnosis has been modeled in literature. Section 1.3 discusses teamwork, and how teams may play a role in diagnosis. Section 1.4 provides a brief discussion of the intensive care environment, teamwork aspects specific to the ICU setting, and current literature about diagnostic error in the ICU. Section 1.5 provides a summary of what studies have been performed in the area of teamwork within the ICU as relevant to diagnostic teamwork. Finally, section 1.6 states the gaps and presents the study aims.

1.2 Clinical Diagnosis and Medical Decision-Making

1.2.1 Process of Diagnosis

To understand diagnostic errors, researchers have examined the diagnostic process. Diagnosis is the decision-making process medical providers use to determine the connection from symptom to syndrome. Diagnostic reasoning is defined as the classification of patient findings belonging to a specific disease (Patel, Kaufman, and Magder 1996). In a review of studies examining the diagnostic process, Kuhn summarized diagnoses as categorization tasks with hypothetico-deductive reasoning and pattern matching based on verbal and nonverbal cues. Each categorization task yields hypotheses based on past experience and knowledge according to the illness script theory (Kuhn 2002). Diagnosis is an abductive process involving rational information-processing models, naturalistic decision-making models, and systems-oriented models (Weaver, Newman-Toker, and Rosen 2012). Diagnosis is a “complex interaction of clinical cognition and diagnostic test” (Podbregar et al. 2001). Recently, the Institute of Medicine determined procedural steps in the diagnostic process including: patient engagement with healthcare workers, information gathering, information integration and interpretation, establishment of an explanatory diagnosis, and communication to the patient (Balogh, Miller, and Ball 2016).

1.2.2 Decision-Making Models and Diagnosis

Research in decision-making has major implications for understanding the diagnostic process, as the diagnostic process primarily involves making decisions. For example, deciding what steps must be followed to find information or deciding when a final diagnosis is reached are crucial decisions in the diagnostic process.

The study of decision-making has incorporated multiple theories for understanding and modeling diagnostic decision-making. Naturalistic decision-making (NDM) theory is a knowledge-based approach which models how decisions are made within real-world situations containing real-world attributes: high risks-benefits, time demands, expertise, inadequate information, uncertain information, ill-defined goals, ill-defined conditions, cue learning, context-dynamic conditions, and team coordination (Klein 1999). NDM involves decision-makers making decisions without individually weighting options while making automatic and nearly instantaneous judgments. NDM has been used to study naturalistic decision-making of firefighters, military leaders, power plant operators, pilots, physicians, nurses, and engineers (Klein 2008). NDM has been applied to study decisions with limited time, high stakes, uncertainty, unstable conditions, and vague goals (Klein 2008). Diagnostic experts use forward reasoning or inferences from data to form a hypotheses, and to relate clinical findings from patient presentations to diagnostic solutions (Patel, Kaufman, and Magder 1996).

The Recognition Primed Decision Model (RPD), a theoretical approach based on NDM, suggests decision-makers compare current situations to previously experienced similar situations to arrive at a representation based on recognition of a familiar situation to select a decision. If a representation is unfamiliar, a more thorough and analytical cognitive approach is undertaken (Cannon-Bowers and Salas 1998).

Studies on diagnostic decision-making mostly have incorporated recognition primed decision-making, and dual decision-making theory (2014). Decision-making in diagnosis involves Type 1 intuitive thinking and Type 2 analytical thinking, however, a natural preference towards intuitive thinking occurs in familiar situations (Croskerry 2009b). Type 1 thinking

incorporates past patient illness scripts and heuristics. Thinking shifts from Type 1 to Type 2 analytical thinking for complex cases that either do not match previous experiences or include contradicting or complex information (Croskerry 2009b). Diagnostic reasoning can fluidly go back and forth between each type of reasoning until a diagnostic theory corresponds to observations (Croskerry 2009b). While most diagnostic decisions utilize both Type 1 and Type 2 thinking, the majority of diagnostic reasoning predominantly uses Type 1 (2014).

Diagnostic errors occur within both analytical and intuitive reasoning (Norman and Eva 2010). The majority of literature within education and psychology report Type 2 as less error prone compared to Type 1 (Graber et al. 2012, Rajkomar and Dhaliwal 2011). Type 1 errors are more common, expected, and less consequential, while Type 2 errors are infrequent, unexpected, and more consequential (Dawson 1993, Croskerry 2009a). Errors are reduced when thinking transfers from Type 1 to Type 2 (Croskerry 2009a). A study of written-case diagnoses, however, found that rapid Type 1 diagnoses were less prone to errors than analytical Type 2 diagnoses (Sherbino et al. 2012).

The approaches to understanding diagnostic errors have, so far, looked at the diagnostic process and diagnostic decision-making. A key gap among previous studies, however, is the focus of the individual decision-maker and not the teams that perform diagnoses. Yet teams perform diagnoses more often than the individual decision-maker (Thomas and Newman-Toker 2016, Balogh, Miller, and Ball 2016). With the increasing emphasis of teamwork in healthcare, this thesis study posits the need to understand the role of teamwork in diagnosis.

1.3 Teamwork and Team Decision-Making

1.3.1 Role of Teams in Clinical Care

Work performed by teams has become increasingly important to improve quality, efficiency, and organizational sustainability (Van Der Vegt and Bunderson 2005) (Desivilya, Somech, and Lidgoster 2010) (Vangen and Huxham 2003) (Tomlinson 2005). The rise in teamwork “mandates further research to better understand how team dynamics and processes

facilitate the achievement of team goals” (Dionne et al. 2004). Teamwork has become essential because of the growth in health care technology, services, professional specialization, managed care, and healthcare networks (Poole and Real 2003). Besides the potential to reduce medical errors, teamwork in healthcare may improve metrics of quality care, such as decreased delays, increased job satisfaction, and increased system efficiency (Sexton, Thomas, and Helmreich 2000), maximizing efficiency and effectiveness of patient care (Apker, Propp, and Zabava Ford 2005).

Teams may be defined as “a collection of individuals who are interdependent in their tasks, who share responsibility for outcomes, who see themselves and who are seen by others as an intact social entity embedded in one or more larger social systems (for example, business unit or corporation), and who manage their relationships across organizational boundaries” (Cohen and Bailey 1997). Within healthcare, teams may be defined as “two or more people who interact dynamically, interdependently, and adaptively to achieve a common, valued goal” (Taplin et al. 2015). A distinguishing feature of teams compared to groups is the use of multiple sources of information, interdependence, adaptive resource management, defined roles, and task-relevant knowledge (Orasanu and Salas 1993). Interdependence is a particularly defining characteristic of teams (Taplin et al. 2015), with interdependent tasks being more efficient in task completion (Campion, Papper, and Medsker 1996) and varying in level of occurrence, from shared interdependence with exchanges of information connecting separately completed tasks, to team interdependence involving active back-and-forth interactions to complete tasks (Taplin et al. 2015).

According to Campion et al. (Campion, Papper, and Medsker 1996), several characteristics are identified for effective team staffing: heterogeneity, flexibility, team size, and preferences. Heterogeneity increases the number of competencies within the team (Hackman 1987, Gladstein 1984), whereas flexibility allows team members to fill in for other providers (Sundstrom, De Meuse, and Futrell 1990, Goodman 1979). Additionally, effective team staffing also is dependent on team size to enable work performance without overstaffing (Sundstrom,

De Meuse, and Futrell 1990, Hackman 1987), and identifying individuals' preferences on working as a team (Cummings 1981, Hackman and Oldham 1980). Studies incorporating team characteristics indicate team composition is related to team effectiveness (Campion, Papper, and Medsker 1996). Additionally, team cognition is positively related to team behavior, motivation, and performance (DeChurch and Mesmer-Magnus 2010).

1.3.2 Benefits of Teamwork

Teamwork leads to a cumulative increase in idea generation, by bringing in different viewpoints and a rich set of methods for problem solving. Additionally, teams help promote redundancy in checking errors and improving safety. Teams determine more optimal solutions and make fewer errors than individuals because team members are more likely to favor the correct alternative (Kerr and Tindale 2004). Group decision-making, in other fields such as marketing and management, is achieved by bringing together various skills and increasing collaboration (Goltz et al. 2008).

Diversity in teams helps complement other viewpoints, leading to increased team efficiency (Eckel and Grossman 2005). Inter-professional teams can reduce inefficiencies such as duplication and fragmentation and help reduce health care costs (Reeves et al. 2008) (Reese and Sontag 2001). Inter-professional teams in critical care demonstrated an improvement in reduced hospital days, admissions, and readmissions (Tieman et al. 2006) (Dietrich et al. 2004). With varied information, knowledge, and expertise, teams are more likely to provide a range of perspectives for decision-making and problem solving (Van Der Vegt and Bunderson 2005). Team decisions for making a diagnosis can lesson cognitive load when time is limited. Additionally, different expertise levels complement other members and has the potential to yield a more complete diagnosis (Kalra 2004). Further, authority hierarchies may encourage careful redundancy checks, even through the use of disagreements in discussion (Kalra 2004).

1.3.3 Challenges in Teamwork

While clear advantages occur by working in teams, there also exists several challenges in realizing the potential advantages of teamwork (Hudson 2002) (Zwarenstein et al. 2000) (Van Der Vegt and Bunderson 2005). Research has indicated several problems in decision-making and diagnosis in teams. Hautz, Kämmer, Schaubert, Spies, & Gaissmaier, (2015) found teams of two diagnosticians typically take longer to arrive at similarly correct solutions for diagnosis compared to individuals performing the same diagnosis alone (Hautz et al. 2015). Social loafing can occur in group decision-making and allows errors to continue unchecked (Kerr and Tindale 2004).

Diagnosis in teams can potentially introduce cognitive errors. Kerr & Tindale found biases present in individuals also can occur amongst teams with the potential for new sources and causes of biases (Kerr and Tindale 2004). Biases which influence individual decision-making can be attenuated or exacerbated in groups. Team decision-making does not prevent individual biases, because some biases are stronger among groups than individual decision-makers (Tindale 1993) (Kerr and Tindale 2004) (Houghton et al. 2000). Evaluative bias may be introduced into teams when comparing the effectiveness of one's team to another team (Dustin and Davis 1970). With authority hierarchies, there also exists the potential to discourage careful redundancy checks by limiting disagreements with others. Biases differ amongst teams based on the decision task and each member's predisposition to individual bias (Kerr and Tindale 2004).

Research on teamwork and communication suggests the importance of explicit communication in developing shared representations and for performing under complex situations (Tschan et al. 2009). During information collection, groups often fail to successfully pool together information held by different team members (Stasser and Stewart 1992), leading to incomplete information and suboptimal decisions (Tschan et al. 2009). Further, explicit communication of information held by different members may significantly improve decision-making.

Other potential characteristics which limit the potential benefits of teams include negative interactions between members, such as behavioral hostility which presents a limitation of knowledge sharing (Caldwell and Atwal 2003) (Atwal and Caldwell 2005). Additionally, ideological differences regarding care may exist between different healthcare professions (Caldwell and Atwal 2003). Such negative interactions manifest when issues unique to individuals are grouped together when forming teams.

Finally, teamwork also can create errors unique to teams. For example, errors found among trauma teams include errors of communication with information loss, vigilance failing to prevent the errors of other members, interpretation due to data gathering issues, and management due to a lack of monitoring by leadership (Sarcevic, Marsic, and Burd 2012). By studying errors unique to trauma teams, the design of supportive information may assist team decision-making by encouraging distributed cognition.

1.3.4 Team Identity

According to Lisak and Erez (Lisak and Erez 2009), team identity is defined as a "common sense of entitativity" (Earley and Mosakowski 2000), or "the sense of one's self definition as a transnational team member" (Shapiro et al. 2002). Team identification is defined as "emotional significance that members of a given group attach to their membership in that group" (Van Der Vegt and Bunderson 2005). Team identity is adapted from social identity theory, which posits social identification to have a strong emotional impact on an individual's activities (Tajfel 1978). According to Desivilya et al., team identity is a "cognitive, emotional and behavioral bond that reflects a sense of "oneness", while team identification is defined as "an individual-level construct representing the extent to which an individual member identifies with the team" (Desivilya, Somech, and Lidgoster 2010).

Team identity also is defined by status: behaviors between members of equal status differ from members with less or higher status (Eckel and Grossman 2005). Team identities are defined by contexts meaningful to team members (Kreindler et al. 2012). Inclusion, "the

tendency of the individual to think of the self in terms of the group and to see group characteristics as applying to the self", is related to team identity. (Ellemers et al. 2013). Higher inclusion is associated with more positive feelings toward the group (Ellemers et al. 2013). With a salient team identity, team members are more likely to exhibit behaviors beneficial to group welfare (Brickson 2000). Ashmore et al. in review, compiled a list of features to describe team identity: self-categorization, evaluation, importance, attachment and sense of interdependence, social embeddedness, behavioral involvement, and content (Ashmore, Deaux, and McLaughlin-Volpe 2004).

1.3.5 Benefits of Team Identity

Lisak and Erez determined team identity is very important for team effectiveness (Lisak and Erez 2009). Members with high team identity view team goals and actions as important considerations in individual actions (Ashforth and Mael 1989).

Team members with strong team identity feel encouraged "to share skills, information, knowledge and other resources with each other, behaviors which are likely to enhance the team's welfare and joint outcomes" (Desivilya, Somech, and Lidgoster 2010). Further, team identity creates promotes cooperative interactions within the team (Tyler and Blader 2003).

Higher levels of team identity with task interdependence lead to greater team performance (Somech, Desivilya, and Lidogoster 2009), and team identity moderates expertise diversity and team learning (Van Der Vegt and Bunderson 2005).

Lisak and Erez determined team identity is very important for mitigating conflict among teams, proposing the influence of leadership characteristics and individual connections within the group towards conflict management (Lisak and Erez 2009). Desivilya et al. found team identity positively associated with conflict management (Desivilya, Somech, and Lidgoster 2010). A literature review of provider surveys found higher team identity enhanced team member abilities to cooperatively work together, whereas, conflict due to incapability of behavior

or beliefs decreased performance as members would withhold information (Mitchell, Parker, and Giles 2011).

1.3.6 Team Conflict Management: Disagreements

Real and perceived conflict, common within teams (Afzalur Rahim, Magner, and Shapiro 2000, De Dreu and Van de Vliert 1997) results from tension between team members due to internal dynamics in a team, and presents a challenge to effective teamwork (De Dreu and Weingart 2003). In conflicts, team members become aware of discrepancies, incompatible wishes, or incompatible desires (Jehn and Mannix 2001).

Conflict may occur because of tasks, relationships, and the process. Arazy et al., in a review of behavioral research, determined task-related conflict is least consistent in demonstrating a reduction in team performance, whereas relationship and process conflicts are shown to inhibit teamwork effectiveness (Arazy, Yeo, and Nov 2013). Examples of relationship conflict include personal taste, preferences, values or style, and task conflicts can occur due to resource distribution, procedures, policies, judgments, and interpretations (De Dreu and Weingart 2003).

Chen et al., when examining whether team conflict can be beneficial or detrimental, found conflict to be dependent “on the level of conflict and the nature of team task” (Chen 2006). Yet, task conflict can improve team performance when “team work involves complex, uncertain, and non-routine tasks” by encouraging increased awareness of issues and options (De Dreu and Weingart 2003). Further, how disagreements are handled among teams is a critical determinant of conflict outcomes (Desivilya, Somech, and Lidgoster 2010).

1.4 The Intensive Care Unit

1.4.1 Introduction: The ICU

The ICU is a complex environment, with potential for adverse events, iatrogenic complications, mortality risk, medication errors, and diagnostic errors (Kalra 2004). Intensive

Care Units (ICUs) “are managed by professionals from multiple disciplines and provide care for critically ill patients with life threatening diseases or injuries” (Kalra 2004). ICUs can be further classified by subgroups of patients: medical, surgical, pediatric, and neonatal intensive care. The potential for errors, however, is similar among subgroups due to similarities among work profiles (Kalra 2004). Studies have provided evidence for and against the similarity. Discrepancy rates, which are differences between post-mortem diagnostic findings and pre-mortem final diagnosis, were found to be similar between a medical ICU and a surgical ICU (Tai et al. 2001, Mort and Yeston 1999, Fernandez-Segoviano et al. 1988). Meanwhile, NICU patients are especially vulnerable to diagnostic errors due to small body size, lack of physiological maturity, and limited compensatory abilities (Kanter, Turenne, and Slonim 2004).

The overall primary objective of ICU care is to monitor, stabilize, and manage the patient (Patel, Kaufman, and Magder 1996). Three levels of objectives and decisions are involved in ICU care: (1) Stabilize: airways protected, respiration maintained, circulation adequate, fluid balance maintained; (2) Identify and treat underlying problems; and (3) Plan a long-term course of action (Patel, Kaufman, and Magder 1996). The ICU treats seriously ill or high risk patients with multisystem problems needing rigorous monitoring and aggressive therapy, and medications with severe side-effects (Patel, Kaufman, and Magder 1996).

A Harvard Medical Practice Study identified ICUs as high-risk zones (Leape et al. 1991). Critical care presents patient safety risks because it involves fast-paced, complex, high-risk decision-making with incomplete data by physician providers with varying levels of critical care training (Rothschild et al. 2005). Severity, illness instability, and frequently high-risk intervention and medications also contribute to risks (Rothschild et al. 2005). For example, ICU patients may receive an average of 178 complex interventions per day (Bracco et al. 2001). Complex medical conditions make intensive care vulnerable to error (Rothschild et al. 2005, Donchin et al. 1995). Adverse events and near misses commonly occur and can turn life threatening in ICU patients (Beckmann et al. 2003).

1.4.2 Diagnostic Errors in the ICU

Intensive care is prone to diagnostic errors because of limited resources, rapid diagnoses followed by treatment, multiple clinicians taking care of a patient, and frequent lab and imaging (Weaver, Newman-Toker, and Rosen 2012). The prevalence of serious diagnostic errors affecting patient outcomes, using the Goldman error classification system, is twice as high in ICU patients compared to other specialties (Shojania et al. 2003). Between 22,600 and 40,500 ICU patients die per year in the United States due to diagnostic errors and many more experience harm, indicating diagnostic errors in ICU form a significant portion of preventable harm in hospitalized patients (Winters et al. 2012). Major diagnostic errors in the Medical ICU include: pulmonary embolism, infection, myocardial infarction, and aortic dissection (Goldman et al. 1983). A retrospective review of MICU autopsies found seven of twelve fatal but treatable errors were caused by unrecognized septic origin (Podbregar et al. 2001).

Diagnosing ICU patients is made more difficult by increased severity of diseases, and high incidence of infections (Combes et al. 2004). Additionally, diagnostic intervention proceeds at a fast pace because of rapidly changing patient states during care (Podbregar et al. 2001) making effective diagnoses challenging. Inhibited ability of the patient to provide medical histories also can cause diagnostic errors in the ICU (Combes et al. 2004, Podbregar et al. 2001).

1.4.3 Teamwork in the ICU

Teamwork and collaboration are important in the ICU. The push for patient safety requires inter-disciplinary teamwork to identify, interrupt, and correct medical errors within the ICU (Rothschild et al. 2006). Quality of care and patient safety can improve through “improved collaboration, communication, congruence and equity” among teams in the ICU (Lingard, 2004). To improve team functioning, it is necessary to understand how interactions occur between professions (e.g. nurses and physicians) and specialties (e.g. ICU and consultants) (Lingard et al. 2004). Team identification also is important for the ICU team, because of “a relationship

between perceptions of teamwork and status in the team” in the ICU (Sexton, Thomas, and Helmreich 2000). It is not known how team identity influences diagnostic teamwork and diagnostic errors.

The ICU team is complex and fluid consisting of core groups and expanded groups of healthcare workers (Lingard et al. 2004). Membership is based on “relative professional roles, immediate needs and tacit ‘rules of play” (Lingard et al. 2004). Sexton et al., in a survey, found 94% of intensive care providers favored an open environment for discussion and rejected steep hierarchies with senior members not open to input from junior team members (Sexton, Thomas, and Helmreich 2000).

The attending physician typically is a respirologist, an anesthesiologist, or other internal medicine specialist, and ultimately is responsible for all major decisions and consequences (Patel, Kaufman, and Magder 1996). Attending physicians also orchestrate discussions and pedagogical lessons while discussing patient care (Patel, Kaufman, and Magder 1996). Resident physicians typically belong to surgery, anesthesia, or generic medicine program on a 1-2 month rotation in the ICU (Patel, Kaufman, and Magder 1996). Residents are primarily responsible for individual patient care (Patel, Kaufman, and Magder 1996). Residents’ level of training differs with training programs consisting of lectures, work responsibilities, and objectives targeting each specific level of training (Patel, Kaufman, and Magder 1996). Responsibilities and authority change with level of training, with residents considered as intermediates and sub-experts compared to attending physicians (Patel, Kaufman, and Magder 1996). Nurses play a vital role administering patient care and monitoring patient status (Patel, Kaufman, and Magder 1996). In addition, nutritionists and pharmacists are a part of the ICU team. Pharmacists monitor drug reactions and act as consultants to attending (Patel, Kaufman, and Magder 1996).

Expertise in attending physicians varies due to different extents of clinical activities and leadership in rounds (Cicourel 1987). According to Cicourel, compared to other contexts in healthcare, authority of the attending is derived from expertise, competence, or specialized knowledge, rather than from bestowed bureaucratic authority (Cicourel 1987). With increased

specialization, there is a need for increased collaboration among experts of different specialties (Satin 1994) (Cooley 1994).

According to Cicourel, ambiguously defined horizontal and vertical authority relationships exist and may conflict with clearly defined boundaries of work in the ICU. Overlaps in roles and boundaries are influenced by the provider knowledge base, technology used, clinical experience, and research interests (Cicourel 1987). Authority and bureaucracy exists within and across different domains of expertise and contribute to professional pride (Cicourel 1987). Understanding the rules of the game also is essential if team members are to move beyond thinking as individuals to begin thinking as part of a team (Lingard et al. 2004)

The nature of communication and interaction between team members can characterize effective teams, yet less is known about how ICU teams communicate throughout daily practice (Opie 2000), including the influences of team interactions in diagnosis. Behind the scenes communication, defined as backstage communication, plays a significant role in care (Ellingson 2003). A significant amount of healthcare teamwork occurs in the backstage. Examples of backstage communication include request for information/clarification, request for opinion, offering of information, offering of patient impression, and request for reinforcement of message (Ellingson 2003). Examples of practices occurring within the backstage include “reading and writing notes, discussing patient’s affect, and sharing information and impressions influence subsequent interactions with patients”. Such backstage communication practices were found to occur opportunistically in “hallways, desk areas, break rooms, and other clinic space not designated as meetings” (Ellingson 2003). Backstage communication is a part of embedded teamwork , where the lines between disciplines or professions are blurred and change over time and context (Ellingson 2003). The influence of backstage communication practices has not been studied in diagnostic error research.

1.5 Teamwork Studies of Diagnosis in the ICU

1.5.1 Cognitive Factors

Several studies have examined medical diagnostic teamwork within the specialties of emergency and intensive care medicine. The majority have examined teamwork within the MICU and provide insights on teamwork and collaboration for diagnostic decision-making.

Patel was the first to study team cognition and the acquisition of expertise gained through group decision-making in the MICU setting, using the methods of work domain analysis and activity analysis. Diagnostic decision-making is characterized by ill-structured problems, uncertain dynamic environments, shifting, ill-defined or competing goals, action/feedback loops, time stress and high risk (Patel, Kaufman, and Magder 1996). Diagnostic decision-making occurs in a naturalistic setting with decisions distributed over multiple cooperative players possessing distributed responsibilities.

Team members have clear delegation of roles and tasks for information gathering, completing actions, and reporting results to the rest of the team (Patel, Kaufman, and Magder 1996). Diagnostic teamwork helps in distributing information and workload among individual team members and artifacts. Diagnostic team decision-making functioning consists of individualized task assessments, problem-solving, and coordination with other levels of the expertise hierarchy (Patel, Kaufman, and Magder 1996). Team cognition or socially distributed cognition can arise from individual cognition, with research suggesting diagnostic teams and individual expert diagnosticians may utilize similar diagnostic strategies.

Christensen performed one of the very few studies examining the effectiveness of team-based decisions in constructing a differential diagnosis within the ICU. Diagnosis performance was found not to improve when teams of physicians discuss and integrate patient information compared to individuals performing the same task (Christensen et al. 2000). Information provided redundantly to multiple team members was found to be communicated more often than unshared information that is crucial to make the correct diagnosis. Therefore, teams offered incorrect diagnostic choices more often for cases containing 'hidden profile' information which

required sharing to make a correct diagnosis through collaboration. Critical information was described as either not provided or not listened to in communication. Christensen concluded that clinical discussions which require information sharing among individuals are susceptible to error.

1.5.2 Communication

Graber et al., in a hallmark review, identified teamwork and communication difficulties as causes for diagnostic errors (Graber, Franklin, and Gordon 2005). Tschan et al. studied the patterns and events of physician groups during diagnosis in simulated emergency cases (Tschan et al. 2009). Tschan found an accurate diagnosis was more likely to occur for teams which engage in more explicit reasoning and 'talking to the room', even if teams did not individually pursue more diagnostic information. Extended communication, in the form of explicit reasoning and talking to the room, were found to increase diagnostic accuracy. Tschan has been instrumental in defining teamwork among groups, and in defining communication behaviors among MICU teams (Tschan et al. 2009). Patient discussions sometimes occur in teams under time pressure. Teams diagnosing patients go through reasoning processes which are at least partially communicated within the group. Tschan indicates lack of deliberate reasoning as a cause of individual diagnostic errors, and found sufficient communication reflecting explicit reasoning may improve diagnostic accuracy. Talking to the room can have a positive influence on diagnostic accuracy (Tschan et al. 2009). In a study on "talking to the room" in emergency response teams, teams were found speaking in a louder voice indirectly to the room about state assessments without directly addressing a specific person (Waller and Uitdewilligen 2008, Artman and Wærn 1999). Talking to the room invites other group members to participate in the diagnostic process, which may increase group attention to discussions, detecting problems, and idea generation (Waller and Uitdewilligen 2008). With increased attention, there is a greater likelihood team members will develop a shared mental model (Artman and Wærn 1999). Tschan hypothesized talking to the room can positively influence

diagnostic outcomes by permitting members to rapidly present situations and provide quick updates of changes, but more evidence is necessary.

Impersonal talking to the room may invite members to voice potential dissents in a less confrontational manner avoiding the appearance of singling out members or “putting someone on the spot” (Tschan et al. 2009). However, relational risks occur in extended communication such as appearing to have superior attitudes, and stating information without explaining (Keyton 1999). With the increased likelihood of catching errors among teams, there also is the potential to expose oneself due to errors becoming transparent, causing providers to ‘lose face’ (Tschan et al. 2009). Standardized communication can help limit the relational risks of group decision-making (Tschan et al. 2009).

1.5.3 Organizational Factors

Cicourel is another key figure in studying diagnostic teamwork. Cicourel examined ICU medical expert discourse towards a diagnosis and treatment plan, and found ICU diagnostic teamwork is an intellectually and socially complex process with influences of status and expertise. That is, “... diagnostic activities are mediated by the bureaucratically shaped social roles of the practitioners” and “part of local, contingent interactional circumstances” coupled with “the physician’s professional identity and sense of pride” (Cicourel 1987). Medical decision-making involves uncertainty with “elegant applications of concepts and facts from the biological and physical sciences, and clinical judgments contingent upon considerable background knowledge but where both sets of resources exhibit formal and everyday experiential properties.” (Cicourel 1987). The medical diagnostic process, as observed extensively by Cicourel, typically occurs over several occasions “...and will usually include a history of present complaints, past illness, a review of organ systems, varying amounts of social and family history, occupational information, a physical examination, and perhaps laboratory tests and x-rays. Medical decision-making, therefore, often takes place over the course of several

occasions despite some kind of preliminary treatment during the first physician-patient exchange.” (Cicourel 1987).

According to Cicourel, diagnosticians train in an organizational framework consisting of hierarchical relationships which dictate when different roles will see the patient and provide oral or written accounts to other team members including the attending physician (Cicourel 1987). ICUs in academic teaching hospitals also face a constant exchange of fellows, residents, and interns (Cicourel 1987), creating variations in knowledge (Cicourel 1987). Additionally, socio-cultural norms and culture may pose barriers to teamwork for diagnosis (Thomas and Newman-Toker 2016).

Christensen further elaborated why professional medical teams benefit from teamwork: it serves clinical and educational function, makes sure relevant information is deliberated, facilitates action towards appropriate and agreeable treatment goals, facilitates training of novices, and provides a larger and more diverse pool of information (Christensen et al. 2000). Significant strengths include ability of team members to attend to and analyze different aspects of a case and take different actions to evaluate potential solutions (Christensen et al. 2000). According to Christensen, teaching hospitals have the potential for better decisions because of collective power in larger and more varied repository of facts (Christensen et al. 2000).

1.5.4 Teamwork Interventions to Reduce Diagnostic Error

Lessons learned from studying teamwork outside of diagnosis may be considered for improving diagnostic teams. However, it has been suggested that the fluidity of diagnostic team membership differentiates diagnostic teamwork from teams previously studied (Balogh, Miller, and Ball 2016). Concluding that literature on the teamwork involved in diagnosis is limited and that many lessons can be applied to diagnostic teams (Balogh, Miller, and Ball 2016), several studies have examined the teamwork involved in making a diagnosis and diagnostic error.

Graber et al. provided a review of possible cognitive interventions to reduce diagnostic errors. According to Graber, teams have the potential to improve diagnostic accuracy, or the

proportion of correct diagnoses, by decreasing cognitive burden through distributed cognition. However, diagnostic accuracy may suffer from other factors such as coercive pressure, low morale, normalization of deviance, and group think (Graber et al. 2012). Graber et al. suggested teams may perform better decision-making, even for challenging cases, if individual members are allowed independent functioning (Graber et al. 2012).

Hautz et al. studied teams consisting of two medical students making a diagnosis for simulated ER video cases and ordering diagnostic tests with simulated results compared to individuals performing the same tasks. According to Hautz et al., diagnostic decisions are usually not made by individuals alone (Hautz et al. 2015). Collaborative work increases diagnostic accuracy. Hautz et al. attributed the decrease in diagnostic error occurrence to teamwork. Additionally, Hautz et al., reported the decrease in diagnostic error occurrence is not because of differences in knowledge, amount of acquired information, or relevance of acquired information when compared to individuals performing the same diagnosis. Collaboration among diagnostic groups helped correct errors by filling knowledge gaps and correcting reasoning flaws (Hautz et al. 2015). Groups also were found to have more confidence in decisions compared to singular diagnosticians. Differences in confidence between diagnosticians could help identify diagnostic errors (Hautz et al. 2015).

1.5.5 Other Considerations: Patient and Provider Characteristics

Complexity increases the risk for medical errors (Kondro 2010). Effect of complexity on diagnostic errors has been studied in controlled settings; however, the effect of complexity upon diagnostic accuracy has not been studied. Complexity within medical decision-making has significantly increased due to clinical discoveries and need for increased decisions in diagnosis, therapy, and prevention medicine (Islam, Weir, and Del Fiol 2016). Complex patients have been described as “one for whom clinical decision-making and required care processes are not routine or standard” (Weiss 2007). Cognitive complexity is the amount of cognitive activity per time (Corker et al. 1992). However, no definition of patient complexity has been established.

Complexity has been described by the number of chronic conditions, medications, and use of resources. But, it is argued that complexity is multidimensional and may be captured by other measures (Grant et al. 2011).

A model of clinical complexity, derived by Islam et al. identifies twenty-four contributing factors of task and patient complexities (Islam 2016): Task complexity factors include: (a) unclear goals, (b) large number of goals, (c) conflicting goals, (d) confusing information, (e) unnecessary information, (f) changing information, (g) urgent information, (h) multiple decision-making options, (i) large number of decision steps, (j) decision conflict, (k) lack of expertise, (l) lack of team coordination, and (m) time pressures. Patient complexity factors include: (a) polypharmacy, (b) significant physical illness, (c) mental anxiety, (d) psychological illness, (e) addiction/substance abuse, (f) older age, (g) health disparity, (h) non-compliant patient, (i) poverty and low social support, (j) heavy utilization of healthcare resources, and (k) difficulty with healthcare system navigation. Chronic conditions also can increase complexity, with over 75 million people in the United States having at least two concurrent chronic conditions (Grant et al. 2011).

In addition to complexity in patient presentation, severity of illness is also of concern. Severity of illness can broadly refer to the degree of a patient's organ system derangement and is generally assessed using a variety of demographic, clinical, physiological, and laboratory variables. However, the definition for the severity of illness may differ based on the purpose of measurement (Vincent and de Carvalho 2010). Interest and use of quantitative assessments of illness severity in MICU patients have grown in the last few years (Vincent and de Carvalho 2010). Prognostic models of patient severity have potential uses for the patient, physician, institution, and national-level of healthcare (Keegan, Gajic, and Afessa 2011). Severity of illness may be measured with systems based on disease, organ, or global (Keegan, Gajic, and Afessa 2011). Two types of severity scores occur in function: outcome prediction and organ dysfunction (Vincent and de Carvalho 2010).

Uncertainty is an inherent part of clinical decision-making due to the incomplete nature of medical knowledge and the nature of interpretations in care, even with the most idealized and careful diagnostic reasoning (Mamede, Schmidt, and Rikers 2007). To reduce uncertainty, diagnostic experts utilize heuristics (Kempainen, Migeon, and Wolf 2003) (Tonelli 1998). Additionally, reflective practice incorporates openness in thinking to tolerate diagnostic uncertainty and ambiguity (Mamede, Schmidt, and Rikers 2007). The understanding about diagnostic uncertainty and strategies to reduce uncertainty remains limited.

1.6 The Gaps

1.6.1 The Problem

Most of the time, human decision-makers are correct (Klein 1999), engaged in pattern matching relevant for diagnosing patients (Eva and Norman 2005) (Klein 1999). However, substantial reductions in preventable harm from diagnostic errors can be achieved by identifying unrecognized causes of error and improvements in reduction methods.

1.6.2 What Remains Unknown

Diagnostic errors cause significant harm and occur in approximately 15% percent of diagnoses, but we have limited knowledge on how to more effectively target, prevent, and mitigate diagnostic errors from occurring. The influence of teamwork in diagnosis and diagnostic errors is not clearly known. In particular, major gaps exist in understanding when and how inter-professional and intra-professional collaboration occurs during the diagnostic process, especially for clinical decision-making portions. Additionally, there is limited knowledge on the perspectives of providers about teamwork and whether providers perceive teamwork increases or decreases errors. According to Singh, a major challenge lies in leveraging teamwork in diagnosis (Singh 2016). In the I.O.M. report on diagnostic errors, the committee concluded the role of teamwork involved in diagnosis is unclear and lessons from healthcare teams in

treatment settings can provide insights for making diagnostic teams more effective (Balogh, Miller, and Ball 2016).

1.6.3 How This Study Helps Fill the Gaps

This thesis investigates diagnostic team structure and functioning among ICU providers by obtaining provider perceptions about diagnostic teamwork. Diagnostic team structure will be identified by asking participants who providers perceive as contributors to diagnostic decision-making and by determining how team composition changes over time. Diagnostic team functioning will be documented by asking ICU providers to walkthrough a typical patient diagnosis in the ICU, with details on the procedural steps and team interactions which occur with other team members. Additionally, perspectives on the influence of patient and provider characteristics on teamwork will be sought.

1.6.4 Conclusion

With limited basis for cognitive errors contributing to diagnostic errors, and limited understanding of how teamwork occurs in the diagnostic process, it is necessary to analyze in depth how teamwork influences diagnosis. The purpose of this study is to describe how providers come together as a team to complete a patient diagnosis. It seeks to determine how diagnostic decisions are made throughout the diagnostic process with inter-professional and intra-professional collaboration by ICU team members in daily interactions as providers work to achieve diagnostic goals, and to problem solve around complex diagnostic presentations. By providing preliminary insights on the role of teamwork in diagnostic decision-making, this study may assist future studies which improve diagnostic teamwork and prevent diagnostic errors.

CHAPTER 2

METHODS

2.1 Methodological Approaches

This qualitative pilot study sought to describe how teamwork influences the diagnostic process. The approach consisted of a qualitative descriptive study with overtones or ‘flavor’ of narrative grounded theory (Sandelowski 2000). Descriptions of participant “perceptions, inclinations, sensitivities, and sensibilities” (Sandelowski 2000) helped derive data-driven findings. Results in the form of themes were generated iteratively during data gathering and analysis. Concepts adapted from grounded theory facilitated in analysis of descriptive data and generation of themes (Glaser and Strauss 2009) and helped avoid any pre-conceived hypotheses or notions during data collection.

Within and cross case analysis was used (Ayres, Kavanaugh, and Knafelz 2003) to compare interview responses. Thematic categories called themes were derived from interviews (Dey 1999). Literature review on MICU teams and diagnostic errors preceded data collection. However, most of the literature review for interpreting team identity, disagreements, severity of illness, and backstage communication followed data coding. The rationale behind this approach of revisiting literature review after completing data collection is to help avoid pre-conceived hypotheses.

Study tools included a printed semi-structured interview guide, a Sony ICD-SX733 Stereo Digital Voice Recorder, Transana™ transcription software, Atlas.ti™ qualitative coding software, Microsoft Word, Microsoft Excel, and Microsoft Visio.

2.2. Sampling Plan

To define the study population of concern, the researcher reviewed diagnostic teamwork literature, discussed study feasibility with a medical intensive care unit (MICU) contact person, shadowed a morning rounds for four hours, and shadowed a nurse practitioner in the MICU.

The researcher found that MICU diagnostic team members, including the attending physician,

resident, fellow, and nurse practitioner roles, performed a range of diagnostic tasks and hence, were found as the population of interest for the interviews. Convenience sampling was chosen given the exploratory nature of this descriptive pilot.

Over the three-month period for this study, there were approximately 15 pulmonary attending physicians, five nurse practitioners, 12 pulmonary fellows, four emergency fellows, and 15 residents rotating through the MICU. An initial target of 20 providers, with approximately four interviews per role, was estimated to provide sufficient data saturation, as well satisfy the limited scope and resource constraints of this study.

Based on grounded theory concepts, the researcher planned to cease interviews upon obtaining data saturation when no new or significant information would emerge (Dey 1999). If data saturation did not occur, then recruitment would have stopped upon obtaining between five and ten interviewed participants per role given the limited scope and constraints of this study.

2.3 Setting: The Medical Intensive Care Unit

This study used MICU as the setting because of the importance of teamwork and the increased risk for medical errors including diagnostic errors as mentioned in chapter one section 1.4.2. While it has been suggested that there are no significant differences in work profile among ICU sub-specialties, and therefore, risks for medical error are similar (Kalra 2004), other literature has suggested counter-points such as the higher risk for diagnostic errors in pediatric ICUs (Kanter, Turenne, and Slonim 2004). Research shows that diagnostic errors in the MICU as worthy of further study (Winters et al. 2012, Kalra 2004).

The study MICU consists of 26 beds within a Midwestern public teaching hospital. In this setting, complex and critically ill patients are diagnosed and treated for conditions including: respiratory failure, sepsis, overdoses, cancers, and bone marrow transplants, etc.

2.4 Institutional Review Board Approval

An Institutional Review Board application (IRB) and Nursing Research and Evidence-Based Practice Committee application approved the study. The unit director and nurse manager approved permission for access to the MICU. After IRB approval, the researcher began study recruitment.

2.5 Recruitment

Recruitment procedures consisted of a mass invitation email to all MICU providers, a mass email to providers specifically practicing as attending physicians, fellows, residents, and nurse practitioners, a presentation prior to a morning rounds, a brief introduction to the study at end of an attending faculty meeting, referral from a contact person, and approximately twelve visits to the MICU provider office to invite voluntary participation.

2.6 Data Collection

As a qualitative descriptive study, data collection sought to understand the “who, what, and where of events or experiences” (Sandelowski 2000) using semi-structured interviews of medical ICU providers. The interviews loosely followed an interview guide. Participant responses were either audio-recorded or extensive notes were written. In addition, memo notes were written during audio-recorded interviews.

Memos consisted of notes written during interviews and later while transcribing interviews to prepare data for analysis. Written notes functioned as a memory tool by the researcher including for reminders of what participants said, considerations for follow-up questions, and summaries for comparison and confirmation of previously made statements. Memos lacked consistent structure or format across interviews.

2.7 Interview Procedure

Semi-structured interviews of MICU providers occurred within the MICU in a private room when available or at workstations if participants preferred. After introducing the study and

performing consent procedures, the researcher asked participants if they would like to voluntarily participate in the study.

Upon agreeing to participate in the interview and confirming readiness to begin, participants reviewed the consent document describing the motivations of this study to understand how MICU providers work together to diagnose a patient. Participants were asked if they had any questions or concerns before continuing. After confirming consent to be interviewed, the researcher asked if they would consent to an optional recording of the interview to aid in data analysis. For those who consented, the researcher interviewed the participants at once or scheduled an interview later. Participants were given a choice to wait if they wanted more time to consider. No inclusion or exclusion criteria were used.

After consent procedures, interviews were performed in a semi-structured format using an interview guide shown in Table A1. First, a warm-up question asked participants to describe their role and regular tasks within the MICU. Each interview began with questions on how a patient is typically diagnosed in the MICU. Follow-up questions were then asked to address specific aspects of teamwork and follow-up on any quotes or concepts of interest to the researcher. Examples of follow-up questions include gaining more details on who is perceived as a part of the diagnostic team, and how diagnostic procedures vary among patients.

The average duration of interviews was 13 minutes and 32 seconds. The shortest interview lasted 9 minutes 31 seconds and the longest interview lasted 40 minutes 54 seconds.

2.8 Participants

Five attending physicians, four fellows, three nurse practitioners, and six residents participated in the study. Data collection ceased at 18 interviews as data saturation was obtained. Interviews were performed over a window of 50 days.

One interview with a fellow was interrupted, at which point most of the interview questions had been addressed and no follow-up was requested or performed. The interrupted interview was included in analysis. Of those that agreed to participate, only one nurse

practitioner and one attending physician were lost to follow-up in email. One nurse practitioner and one fellow agreed to participate later, but did not initiate follow-up. One attending physician and one nurse practitioner did not consent to audio recording. Instead, the researcher recorded their responses as written notes.

2.9 Data Preparation and Analysis

2.9.1 Summary

Data preparation and data analysis occurred concurrently and iteratively as a feature of qualitative descriptive studies (Sandelowski 2000). Data preparation consisted of transcription and coding while data analysis consisted of interpreting themes before and after coding based on interview responses and memos.

In addition to final theme derivation upon completion of coding, preliminary themes also emerged during interviews and transcriptions in the form of written memos. Therefore, preliminary themes from memos helped generate codes which in turn defined and supported final themes.

2.9.2 Transcriptions

Interviews were transcribed verbatim using Transana™ transcription software (Woods D 2012) with time stamps marking change of speaker. Transcription aided the researcher to review the data, add to the written memos, analyze codes and quotes, and de-identity the data.

2.9.3 Preliminary Themes

Analysis began during interviews, transcription, and review of finished transcriptions. As introduced in section 2.6, written memos were created during interviews. In addition to use as a memory aid, memos also contained the first documentation of ideas for new or common themes. Preliminary themes helped summarize participant responses and descriptions from interviews and were determined by categorical relationships within and across interview cases

(Dey 1999). Such themes were developed from extraction of similar or contradicting statements, and examining them in-depth in further analysis.

After completing data gathering and transcription, interview transcripts were coded.

2.9.4 In-Vivo Coding

The researcher iteratively coded the transcribed text files using in-vivo coding in Atlas.ti™ qualitative data analysis software (2016) based on open grounded theory (Corbin and Strauss 2008). Coding was performed at the level of sentence or paragraph to further develop preliminary themes, with the addition of any new themes necessary to describe diagnostic teamwork. The qualitative coding procedure was derived from Miles and Huberman (Miles and Huberman 1994).

The coding procedure consisted of numerous stages of collaboration between the researcher and a research mentor, including iterative modifications to the coding guide. Explicit phrasing was used for the majority of codes in an attempt to avoid potentially incorrect interpretation of participant statements by the researcher. The coding guide was refined throughout coding to better reflect the interview data and the study research questions. Code categories were grouped into categories based on themes that emerged during coding. Throughout all iterations of study coding, the guide changed as new codes were considered, combined, and eliminated from study. Code overlap was not of concern for this study.

The creation of codes began with reviewing memos and reading transcriptions to derive an initial coding guide. Next, the researcher and research mentor reviewed and re-focused the coding guide to better reflect teamwork in diagnosis as opposed to just procedural steps in diagnosis. The researcher then applied the coding guide to half of the interviews: eight interviews in total, consisting of two interviews per role. In an effort to avoid coding bias and promote inter-rater reliability, the researcher's mentor received the coding guide and coded the same eight interviews for comparison with the researcher's results. The researcher compared each coding result and anecdotally found significant agreement. Small differences arose in

coding which resolved through removing codes not of direct interest to the study questions and adding instances of codes that were initially missed by the researcher. After combining the separately coded interviews, the researcher coded the remaining eight interviews and derived a final coding guide (Table 1).

The final code categories within the final coding guide are shown in Table 1 and include diagnostic team identities, team interactions between roles with reasons why each teamwork interaction occurs, team interactions between same roles with reasons why each teamwork interaction occurs, patient and provider characteristics considered potentially to impact the diagnostic process or teamwork that is involved, and features of diagnosis or teamwork that providers considered to lead to medical error.

Table 1: Finalized qualitative coding guide applied to transcribed semi-structured interviews in preparation of data analysis.

Code Categories (Families)	Codes	Definition
Identified Error Sources	Error: Being Too Confident	An error may arise due to over-confidence, which causes reluctance to work as a team and try to “run the show” themselves.
	Error: Fail to Carefully Listen	Error to not listen to others when they provide information important to reach the correct diagnosis, whether entirely or partially missing important information.
	Error: Fail to Communicate Information Correctly	Error caused by miscommunication such as incorrect emphasis on importance of information.
	Error: Fail to Share Crucial Information	Failure for team members to provide information, either because it's not perceived as relevant or in forgetting to do so (e.g. Resident towards the Attending).
	Error: Not Sufficiently Good History	One limitation of diagnostic history-taking is in not getting a very good history (perhaps not an 'Error Source', but related).
Patient and Provider Characteristics	Complexity	Complexity was self-defined by participants. Coded phrases included descriptions of complexity and how it changed the diagnostic process. Examples described include patients presenting with co-morbidities, unusual presentations, rare diseases, too much information, and more severe illness.

Table 1 – continued.

	Disagreements	Task disagreements that occurred between team members including reasons why they occur, examples of causes, and how they are resolved.
	Severity of Illness	Severity of illness were qualitatively defined by participants as 'very' severe and 'less' severe. Coded phrases included descriptions of severity and how it changed the diagnostic process.
Diagnostic Team Identity	Attending Physician (Team Identity)	
	Consultants (Team Identity)	
	Dietary Staff (Team Identity)	
	Fellow (Team Identity)	
	Intern (Team Identity)	
	Medical Students (Team Identity)	
	Nurse Practitioners (Team Identity)	
	Nurses (Team Identity)	
	Nutritionists (Team Identity)	
	Pathologist (Team Identity)	
	Patient (Team Identity)	
	Pharmacists (Team Identity)	

Table 1 – continued.

	Physical Therapists (Team Identity)
	Radiologist (Team Identity)
	Resident (Team Identity)
	Respiratory Therapists (Team Identity)
Diagnostic Teamwork: Inter-Role	Attending – Consultants
	Attending – Fellow
	Attending – Intern
	Attending – Medical Students
	Attending – Nurse
	Attending - Other Department
	Attending – Pathologist
	Attending – Patient Family
	Attending – Radiology
	Attending – Resident
	Attending – Team
	Fellow – Consultants
	Fellow – Medical Students
	Fellow – Nurse Practitioner
	Fellow – Nurses
	Fellow - Physician Assistant
	Fellow – Requester
	Fellow – Team
	Nurse Practitioner – Attending

Table 1 – continued.

	Nurse Practitioner – Consulting
	Nurse Practitioner – Nurse
	Nurse Practitioner – Requester
	Nurse Practitioner – Resident
	Nurse Practitioner – Team
	Resident – Consulting
	Resident – Fellow
	Resident – Medical Student
	Resident – Nurse
	Resident – Patient Family
	Resident – Pharmacy
	Resident – Radiology
	Resident – Respiratory Therapist
	Resident – Team
	Team – Consulting
Why (Inter-Role): Bounce ideas or get second opinion	Informally request or provide perspective on diagnostic information without expertise in mind. Discussing “here’s what I know, here’s my plan, and what do you think? Would you do this?”
Why (Inter-Role): Collect HPI together	Work together to collect the history and physical information (HPI) at the same time.
Why (Inter-Role): Determine final diagnosis together (open discussion)	Open discussion occurring with all team members, such as during morning Rounds. Part of the regular diagnostic process.

Table 1 – continued.

	Why (Inter-Role): Different sub-areas of expertise	Request for someone's perspective specifically because of their expertise knowledge regarding certain patient diseases or conditions.
	Why (Inter-Role): Discuss incoming patient case	Discuss an incoming patient case including any known information such as patient history and reason for admittance.
	Why (Inter-Role): Education	Share diagnostic cases for educational opportunities. In formal contexts but also informally sharing interesting cases with colleagues.
	Why (Inter-Role): Exchange viewpoints on order results	Actively request and provide input on order results by conferring with the radiologist or pathologist.
	Why (Inter-Role): Experience/Familiarity with certain things	Some staff such as colleagues may have more experience with certain conditions.
	Why (Inter-Role): Expertise with certain patient conditions	Confer with other MICU staff because of their specialized knowledge and expertise for certain conditions. For examples, diagnoses relevant to blood infection will regularly involve infection consulting services. Also seen in attending physicians, as some may refer to colleagues from the same specialty background but have more experience and understanding for the diagnosis or treatment of specific conditions such as pulmonary fibrosis.

Table 1 – continued.

	Why (Inter-Role): Gather Information from other role	Exchange of diagnostic information (with no considered amount of perceptive relevant for diagnosis).
	Why (Inter-Role): Go examine in-house pre-admitted patient	The fellow may include the resident or nurse practitioner who will be assigned the patient along to examine an in-house patient to determine if they should go to the MICU based on their condition.
	Why (Inter-Role): Help out with HPI	Assist another provider with the collection of an HPI. Collected together as opposed to collected separately for comparison.
	Why (Inter-Role): Learning issues event	Coming together as a team, the attending physician discusses cases for educational benefits.
	Why (Inter-Role): Other staff have more experience in this/the ICU	If a provider doesn't typically work in the MICU, or they are new, they will confer with others for their perspective as help for what to do or how to do it.
	Why (Inter-Role): Request patient admission	Interaction between a staff person who requests a patient be admitted, and the fellow who performs triage over the phone and determines acceptance based on eligibility and availability of beds.
	Why (Inter-Role): Review data and conclusions	Review the data and conclusions of diagnostic choice (done by attending physician for final approval of diagnosis and care plan).

Table 1 – continued.

	Why (Inter-Role): Uncertain about diagnosis	Check with another role, usually a 'higher-up' such as Attending, about doubts and uncertainty about what to do next. (May be able to combine with Contraindicating or Complexity codes).
Diagnostic Teamwork: Intra-Role	Attending – Attending	
	Fellow – Fellow	
	Nurse Practitioner - Nurse Practitioner	
	Resident – Resident	
	Why (Intra-Role): Bounce Ideas or Get Second Opinion	Ask someone for their perspective or 'here's what I have, here's what I plan to do, is that what you would do'.
	Why (Intra-Role): Complex case	Go seek a colleague's help for a complex case.
	Why (Intra-Role): Contradictions	Go seek a colleague's help for figuring out contradictory information in a case.
	Why (Intra-Role): Data Doesn't Make Sense	Go seek a colleague's help for figuring out data that doesn't make sense (rather vague).
Why (Intra-Role): Different Sub-Areas of Expertise	Go confer with colleagues who have familiarity of specialty with certain things (to note, occurs Inter-Role too, as I recall one Attending remembering a Resident who has specific experience with something that they don't; this sounded really interesting).	

Table 1 – continued.

	Why (Intra-Role): Difficult Case	Go seek a colleague's help with a difficult case (rather vague). May combine with 'Second Opinion' or 'Bounce Ideas'.
	Why (Intra-Role): Inexperienced Assistance	Go seek a colleague's assistance because they are new (with the implication that they don't know what to do next or how to do it, because they are new.
	Why (Intra-Role): Major Decisions with Limited Time	A little vague and possibly can combine with another code: sounded sounds sort of like "this will influence major decisions, so I need to get this right and I don't have much time"
	Why (Intra-Role): Say it Out-loud	Walkthrough a case with someone else, more to have to mentally revisit and structure all information rather than to get their opinion.
	Why (Intra-Role): Share Rare Cases	Share rare or interesting cases with colleagues. E.g. talk about an interesting diagnosis a week later when running into another Resident.

2.9.5 Final Themes

AN inductive analysis of was performed on resultant codes coding, inspired by grounded theory (Glaser and Strauss 2009). Preliminary data analysis consisted of emergent themes during interviews based on what participants described, while final analysis was performed after all interviews and coding were completed.

Emergent themes were drawn from relationships occurring within and across categories or cases (Dey 1999). After looking through each instance of code, counter-points were sought after: e.g., if uncertainty was described as increasing teamwork, any alternative descriptions or codes for which uncertainty was said to not initiate teamwork also were sought after. Final themes described team development, structure, and functioning for diagnostic decision-making. Quotes that adequately captured the essence of emerging themes regarding diagnostic teamwork and patient and provider characteristics were selected for illustration of findings. Finally, a model was created using Microsoft Visio to visually demonstrate the themes of diagnostic teamwork (Figure 1).

To illustrate the analysis process of theme generation and development, consider an example theme on the role of clinical backstage in making a diagnosis, which first emerged during the initial transcription and memo generation process. First, the researcher recognized from conducting the interviews, writing memos, and reading transcriptions that diagnostic contributions occur not just from providers directly assigned to a patient's care, but also from informal and undocumented discussions from providers not directly assigned to a patient's care. This finding, before any coding took place, is the preliminary theme on the role of clinical backstage. Then, the researcher created codes to describe the interactions between roles with reasons why. Then, each code was compiled into code categories with inter-role teamwork and intra-role teamwork. Next, the researcher evaluated the coding categories and each individual code segments to find trends and quotes that describe the clinical diagnostic backstage, which resulted in the final theme on the role of clinical backstage in diagnosis.

2.10 Validity

As a qualitative methods study, validity was examined and reflected in design (Maxwell 1992). Descriptive validity was considered by making efforts to code and quote phrasing explicitly with minimal interpretation. Because this study examined provider perceptions, in some instances, participants would at first appear to describe diagnostic teamwork, when in reality they were discussing treatment teamwork. In such instances, the researcher prevented a potential misinterpretation by noting the differences while transcribing, and in reading the entire transcript before coding.

Interpretive validity was considered by attempting to avoid any pre-conceived researcher bias in reflection, such as whether or not teamwork increases under certain circumstances. Concepts from grounded theory were utilized to avoid any pre-conceived hypotheses regarding diagnostic teamwork. For example, while this study is interested in understanding instances in which teamwork increases, it also was of interest to learn of situations for which teamwork decreases in occurrence.

Finally, efforts were made to reduce researcher bias through collaboration between the researcher and research mentor.

CHAPTER 3

RESULTS

3.1 Summary of Results

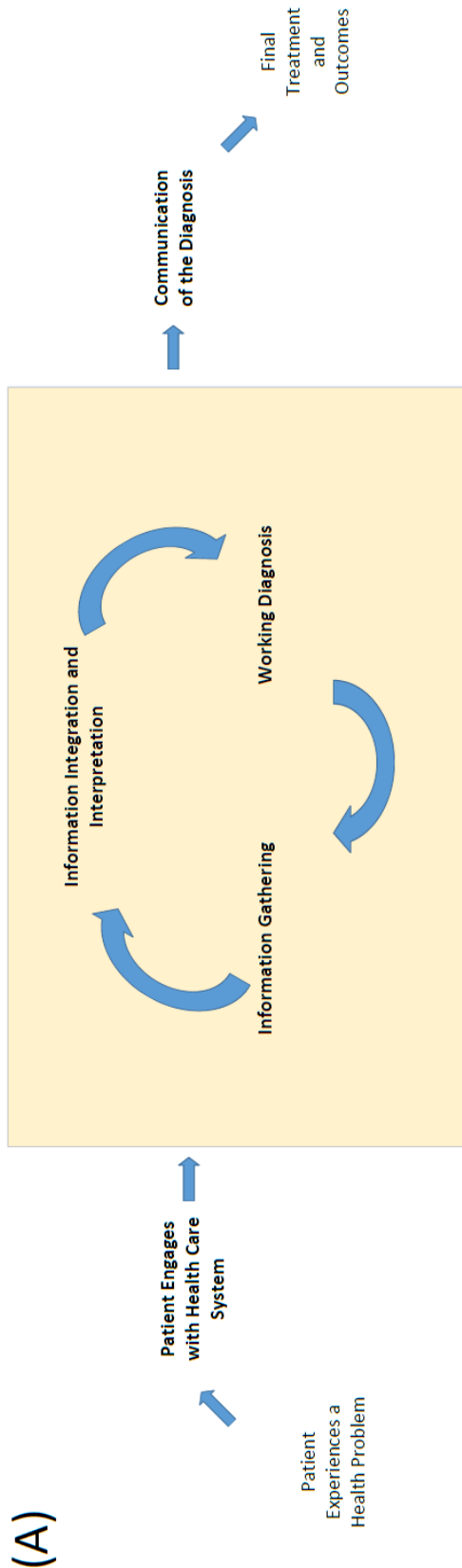
This study sought to understand how teamwork influences clinical diagnosis. This was accomplished by obtaining provider perceptions regarding diagnostic teamwork to understand team structure and functioning. Several emergent themes were obtained and used to create a model of teamwork in diagnosis, shown in Figure 1. Figure 1 is a model of diagnostic team structure, functioning, and influences of provider uncertainty and patient severity of illness. Additionally, Table 1 presents the final coding guide developed in this study. The following section themes that emerged in this study are discussed along with exemplifying codes to support the findings.

The next few paragraphs provide a brief summary of the findings. Most providers discussed that teamwork is important and beneficial for diagnosis, suggesting that diagnosis inherently involves a lot of teamwork in the academic setting. But participants appeared to experience difficulty in determining the line between treatment and diagnosis.

To connect team structure to functioning, team identity also was explored. The primary diagnosticians were asked to identify who they considered a part of the diagnostic team and the list of roles were identified. Results presented here support literature on team identity, with two roles discussed at length regarding the nature of team identity and diagnostic contributions of nurses, patients, and patient family.

To define diagnostic team functioning, team activities were modeled based on descriptions of how teams work together to make a diagnosis. Results showed they work together minimally to complete straightforward diagnoses but can also reach out for assistance. Anecdotally, two of the most common reasons included wanting to get a second perspective

Figure 1: Part one of two.



(B)

	Requester for Patient Admission	Fellow	Attending Physician	Primary Staff: Nurse Practitioner or Resident	Patient	Patient Family
Requester for Patient Admission	Requester for admission, provides information	Things call or page, provides information	Accepts patient information	Receive patient information	Asks with info	Learn diagnosis
History and Physical (HPI)	Act or Collect own HPI	Act or Collect own HPI	Act or Collect own HPI	Act or Collect own HPI	Asks with info	Learn diagnosis
HPI Update	Receive HPI update	Receive HPI update	Receive HPI update	Receive HPI update	Asks with info	Learn diagnosis
Orders	Order: Lab, Imaging, Consulting	Order: Lab, Imaging, Consulting	Order: Lab, Imaging, Consulting	Order: Lab, Imaging, Consulting	Asks with info	Learn diagnosis
Presentation to Attending	Present case to attending	Present case to attending	Present case to attending	Present case to attending	Asks with info	Learn diagnosis
Final Approval	Final approval	Final approval	Final approval	Final approval	Asks with info	Learn diagnosis
Communicate Diagnosis to the Patient	Comm. diagnosis	Comm. diagnosis	Comm. diagnosis	Comm. diagnosis	Asks with info	Learn diagnosis

(C)

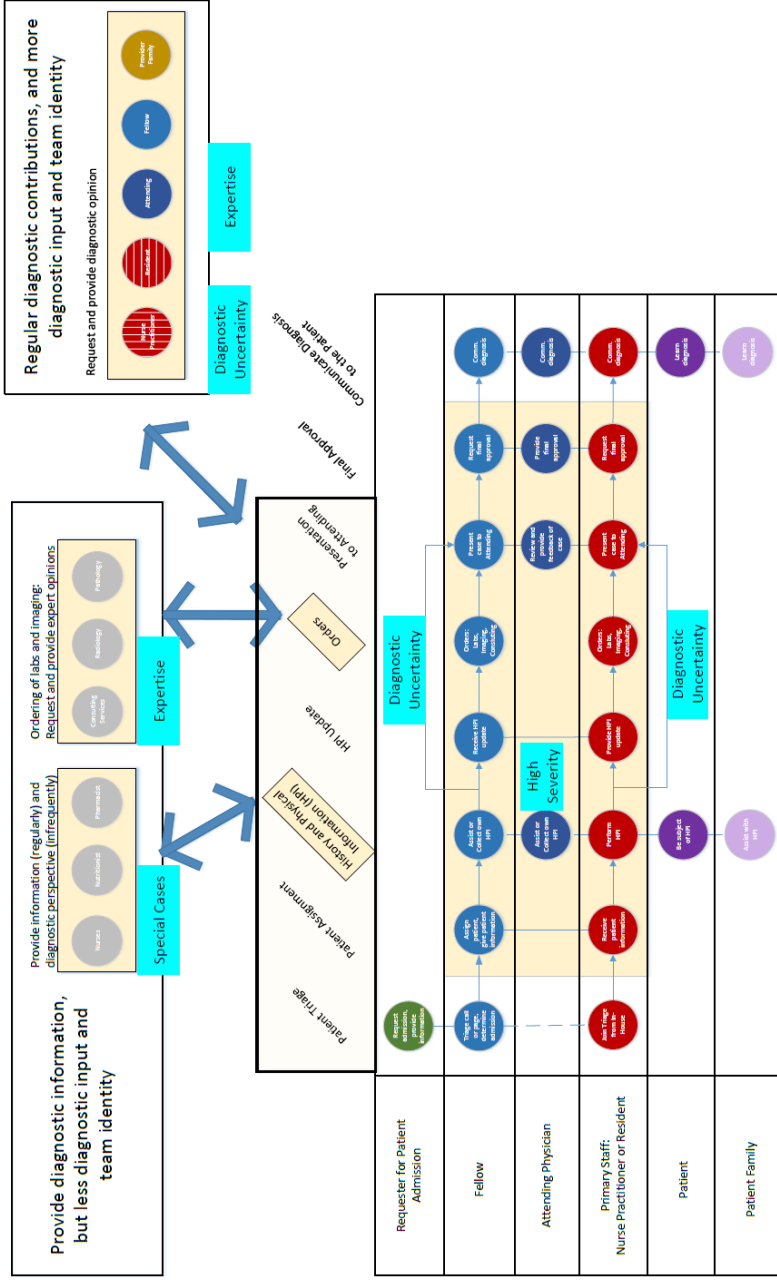


Figure 1. Model of teamwork structure and functioning performed to diagnose patients in the medical intensive care unit with straightforward diagnoses (B) or cases that include higher severity of illness, diagnostic uncertainty, or require seeking expertise from other providers. The shaded areas within (B) and (C) correspond to procedural steps and interactions of diagnostic decision-making, as based on the model derived from the Institute of Medicine's conceptualized model of diagnosis (Balogh et al. 2016). Bold text within (A) corresponds to diagnostic procedural steps included in (B) and (C). (B) and (C) present team interactions that occur among various roles involved in diagnosis, as well as what diagnostic contributions occur from staff, patients, patient family, and others who are perhaps not considered a part of the MICU diagnostic team. Solid line interactions present regular interactions, whereas saw lines indicate teamwork that is not regular and occurs for specific circumstances, such as when the attending physician joins for the HPI at the time of admission for severely ill patients. From the beginning left, a patient admission to the MICU is requested from the Fellow, followed by patient assignments to either the resident or nurse practitioner, who remains the patient's primary provider during their care. Diagnostic work occurs, and finally the diagnosis is communicated to the patient.

about a diagnostic plan and specifically seeking expertise for certain conditions. These concepts are reflected in Figure 1. Examples are included with quotes to demonstrate when they ask for help from their team under different situations.

Situations considered to influence the engagement of teamwork also are discussed, which may include situations when there are variances in patient presentation and cases where provider characteristics change diagnostic teamwork. These demonstrate how teamwork varies based on patient cases and how providers feel, which are both reflected in the model in Figure 1.

Finally, participants also had opinions on when diagnosis and diagnostic teamwork may fail. These were compared to literature and point to new questions and studies for diagnostic teamwork.

3.2 Theme 1: Teamwork in Diagnosis is Regular, Important, and Flexibly Defined

A first theme emerged describing diagnostic teamwork as always occurring, important for outcomes, and presenting some advantages and disadvantages over individuals making a diagnosis. Teamwork was described as an important and constant part of the diagnostic process with contributions varying based on level of involvement. Further, the teamwork involved in treatment and diagnosis does not always exist distinctly.

3.2.1 Finding 1: Diagnosis is a Team-Based Activity

Participants described the diagnostic process as interactions between roles with either direct contributions of diagnostic decision-making through perspectives, or indirect contributions in providing diagnostic information. In other words, none described themselves as completing the diagnostic process by themselves. Participants described working with other roles with the minimum of simply exchanging information relative to performing a complete diagnosis; for example, the fellow providing patient cases to the resident or nurse practitioner, and the

resident or nurse practitioner updating the attending on diagnostic plans for final approval. This was described as straightforward for standard, less complex diagnoses.

Anecdotally, some went as far as to suggest that all decision made within the MICU involve working with other team members, consisting of all members of MICU providers from the primary points of contact, consulting services, and ancillary staff. This includes all MICU providers from the attending physicians, fellows, residents, nurse practitioners, consulting infection specialists, nurses, nutritionists, pharmacists, and more. A distinction was described whether or not the involvement of others involved contribution to decision-making, such as being involved in review, and agreeing or disagreeing with a diagnosis. Recognizing how every MICU provider contributes in at least some way, participants described how a patient's differential diagnoses is first reached by the fellow with an incoming patient diagnosis or the nurse practitioner or resident upon performing the history and physical (HPI). Regardless of the amount of decision-making, the contributions of all team members were described as a significant and positive characteristic of academic medicine:

Resident: *"I feel like there's a ton of collaboration that happens with...all the members of the patient care team, and whether or not it directly helps with finding... 'this is the diagnosis for this patient'. I think it helps with the gathering of information and it helps with the flow..."*

Nurse Practitioner: *"I will come up with my own diagnosis and share it with others who may also agree or disagree with what I've come up with, so usually the symptoms that people present with can be symptoms of multiple things, so you kind of have to narrow things down bit by bit by ordering more tests that will then lead you further down the path, so it's kind of a stepwise action actually that will go through multiple people. And then, as a team we usually pretty much come up with the diagnosis, the ultimate one."*

Further, a setting was described in which open collaboration is encouraged from all levels of expertise. Teamwork was framed as occurring in an open atmosphere consisting of requested and solicited contributions from 'everyone' to promote collaboration and teamwork for

patient treatment and diagnosis. For example, the environment was described in a way that 'losing face' is not likely to occur, given the comfort-level and encouragement from the attending physician. Thus, teamwork does not appear to be discouraged. In addition, teamwork was thematically described as occurring between a patient's primary care team consisting of a single attending physician, a fellow, and a resident, along with other teams who are not involved with that patient's direct care:

Fellow: "I'd say we have a really good team environment here where people feel comfortable talking to each other. And last time I was on call, we had a case of a person [who] had some labs that just didn't quite make sense altogether, like the patient looked okay but each lab individually was ok, but they just didn't go together to kind of come up with one conforming, all-encompassing diagnosis. And so, the Resident and Intern and I just kept brainstorming all night long out-loud."

3.2.2 Finding 2: The Importance, Benefits, and Limitations of Teamwork in Diagnosis

Participants also suggested the importance of teamwork within healthcare and specifically regarding diagnosis. A team setting occurs and is promoted through discussions before providers begin MICU rotations, active requests for inputs throughout care, a willingness to change opinions, an openness for disagreement, and recognition that no single provider is infallible or knows everything. Teamwork was described as important in all of healthcare including diagnosis with importance related to diagnostic benefits.

Benefits of teamwork towards diagnostic decision-making and diagnostic outcomes were compared to individuals, such as the addition of multiple viewpoints and perspectives coming together in agreement or disagreement. The importance of gaining input from multiple perspectives by attentively listening and requesting was perceived as a standard in best practice, and necessary to reach the correct diagnosis by considering the perspectives of team members who are actively thinking and participating. Other benefits include the ability to facilitate training among different levels of learners, increased completeness in obtaining

diagnostically-relevant information, and redundancy of work. Such positive features occur despite the negatives of increasing complexity involved in care.

Attending: *“So, you have a team and I think a good team - everyone is thinking, everyone has their own views, so you have some hearing of those views and come to a decision and you move forward.... a group of smart people is probably the best at making a decision, as opposed to one person, so if you are really smart, you kind of listen to what everyone has to say and eventually you have to make a decision...”*

Resident: *“I guess when we get other teams involved it can be very helpful because they can think of things that we haven't thought of. Kind of lead us down the right path, figure out what is going on. Sometimes, it does make it more complex because they make think one thing, we may think another thing, and another team may think something else. Or they may disagree on what's the right treatment path or... - so it can make things more complex, but overall I think it's probably a good resource that we have all of these types of specialties that can help us when we're in these conundrums when cannot figure out what's going on.”*

Redundancies of work obtained through teamwork are seen as hallmarks of good care despite the increased task complexity among teams. This was described as a positive feature with advances that occur from overlapping functions of teamwork such as HPI, and a necessary factor given the limited abilities of patients to participate in the diagnostic process:

Fellow, on being asked who performs the HPI: *“Anyone that comes to the hospital; there's multiple providers that tend to repeat the same steps. And it's not meant to be a time-waste, it's more of a commitment to collaborate the story multiple times to make sure I'm not missing something, because there's oftentimes - sometimes you could've asked a question in a different way or sometimes we don't ask the right questions, really, that eventually you get this additional history and that'll make the diagnosis. More infamously, it seems that sometimes even the patients, after being asked the exact same questions three times, after the third time*

[say] 'oh, I think I forgot to tell them this', or ' I thought I forgot about this', so sometimes it's even just the repetition can be a cue to the patient."

However, while some suggested the benefits and importance of teamwork in diagnosis, some also stressed times for which teamwork may not be the best option in practice. A counterpoint is the potential for over-reliance on other's opinions and a lack of independence, which was described as important for MICU providers to have. Some mentioned the benefits of gaining autonomy or competence in balance with teamwork by first actively considering options. This balance between autonomy and teamwork was described as an increasing consideration as expertise is gained by the resident and fellow physicians, in comparison to reaching out to the more experienced attending physician for assistance:

Resident: *"Bring in as many people as you want, but you have to work it through first, you don't always want to rely on other people, too.... It's a part of medicine."*

Fellow: *"We're required to consult with our Attendings on every patient, so they - but getting them involved earlier in sicker patients is always a good thing - at the same time you want to have some level of autonomy. As you get further along in your fellowship, you feel comfortable managing sicker patients."*

Finally, some participants described the importance of getting along with their team, with ramifications towards teamwork effectiveness based on the relationships between team members. The merits of amicably maintaining working relationships with other team members was identified as important in order to feel open towards contributing and listening to others' inputs. In addition, the recognition of teamwork and the need to get along through contributions may be described by the attending physician at the beginning of rotations, presenting a hierarchical support that encourages and requires teamwork from all roles:

Resident, when asked if they had any other comments or thoughts to share about teamwork or diagnosis: *"Any team that you work on in medicine, I guess especially in the ICU,*

you feel - if you feel like you are on good times with whoever you are working with, the more likely you are to approach to that person with an idea. *And I've just been lucky that I've worked with people who have been easy to work with, so I think that's why I've had this experience."*

3.2.3 Finding 3: Differentiating Teamwork of Diagnosis and Treatment

A. overlap and unclear distinction arose when participants would describe teamwork involved in treatment and in diagnosis within the MICU. Participants would realize mid-statement that they were talking about treatment teamwork when asked about diagnostic teamwork while pointing out that it is hard to descriptively separate each mode of teamwork. To note, these findings occurred throughout interviews with somewhat rare frequency, approximately once per interview:

Nurse Practitioner, when asked how they taught who to work with to make a diagnosis: *"Just kind of over time during my orientation, like for - like for diabetic acidosis, there's a protocol that says 'the insulin drip will run like this, the Nurse will titrate by this' and you just basically order it and it goes. So there's not a whole lot of reasons - I mean we always tell our Attendings the plan, regardless of what the patient is, but that's a little more straightforward than say 'oh this patient has this wrong, this wrong, this'... So I may be getting off of diagnosis and actually be going into treatment there [laughter], now that I'm thinking about it."*

Resident, when asked about diagnostic teamwork and they respond with treatment examples: *"Oh, treatment, not diagnosis. I mean it's hard to kind of separate them..."*

Some participants explicitly made the distinction, noting that diagnostic teamwork rarely mimics treatment teamwork. Situations for which behaviors would differ included who they would refer to for advice or perspective regarding treatment as opposed to diagnosis. Clear deviations regarding diagnostic and therapeutic team interactions were described, for which some roles provide significant therapeutic input, but little to no diagnostic input. Further, such variances were found to differ among participant roles. For example, one resident described

how they rarely refer to colleagues for diagnostic input, while another resident suggested they refer to colleagues more commonly for less clear patient cases:

Resident: *"I think if we have questions depending on the team, if you're friendly with your co-Residents, you might bounce things off the wall, bounce things off each other.... I think more than diagnoses, it happens more often with decisions to do a particular intervention. Like dosing or re-dosing diuretics or things like that. Or which antibiotic to use, "do you think this one is good enough, what is your - would you pull the trigger on doing this intervention at this point or would you wait a little longer?" I think that's where I - I don't know, those decisions are more [grey] when you're trying to come up with a diagnosis".*

Resident: *"I have discussion[s] with other Residents on the team as well... just conversations with other Residents if there's a particularly interesting or difficult patient in the sense that it's not really clear what's going on, we can talk amongst ourselves even though they're not directly involved with the care for that patient."*

Finally, participants described a cyclical nature of treatment and diagnosis wherein an initial diagnosis upon admission will normally change throughout a patient's stay as a regular path of continued care. The nature of making a diagnosis and treatment are dependent on time availability to perform a differential diagnosis, which is influenced by patient stability. In other words, some diagnoses are urgently made out of necessity in order to initiate treatment and then continually modified and updated throughout care to more accurately reflect the situation. More careful and lengthy considerations of diagnostic decision-making occur with more time allowed. The benefits of more time were described as providing more time to reason, more time to collect more information in the form of further tests and imaging, and the ability to ask for assistance when uncertain:

Attending, answering when they would confer with colleagues: *"Sometimes, you know you're not sure, but the patient is doing okay and you can afford a little bit of time to do some measures that you can test your theory and see if you're right or not. Sometimes, you can afford*

that time, and other times you can't. So let's say if you think someone has congestive heart failure, but you're not really sure, so you might give them the diuretic and see if they do better, for example. So you're not really sure, but you test your theory. But sometimes things are more acute and you don't have the luxury, unless [in] the case I might ask for someone's opinion."

3.3 Theme 2: Team Identity Corresponds with Diagnostic Contributions

A second theme emerged for the relationship between diagnostic contributions, and between team identities perceived by others and self-perception by the four roles interviewed. This theme consisted of study findings relevant to team structure: MICU provider role membership, rotations of involvement in the MICU, and the perceived identities as a part of the diagnostic team. Four cases are of particular interest among provider perceptions and are discussed further: nurses, patients, patient families, and other sources.

3.3.1 Finding 1: MICU Provider Rotations

The structure of the MICU care team and durations of rotations within the MICU were obtained. The MICU setting consisted of a 26 bed unit with two MICU care teams, although cross-coverage of patients between teams was described to not occur. Each team consists of two attending physicians board-certified in critical care medicine, up to four full critical care fellows, up to three second- or third-year residents (two regularly staffing the MICU, with an occasional third from Family Medicine or Emergency Medicine), one intern, one or two nurse practitioners, one physician assistant, consultation services (including renal, infectious diseases, cardiology, surgery), nurses, medical students, and physician assistant students. The classification of Advance Practice Providers (APPs) included the nurse practitioners and physician assistants; however, physician assistants were not included in this study in recruitment or data collection.

Rotations within the MICU occur with different lengths for each role. Attending physicians rotate for one to two weeks in the ICU, the fellows rotate four weeks, and the

residents rotate two weeks. Among each team's two residents, one staggers a week behind the other resident to create continuity within the team. For an emergency medicine resident, they may have three months total of their study allocated to critical care rotations consisting of two week stints. Nurse practitioner rotations were not collected.

3.3.2 Finding 2: Diagnostic Team Identity

Participants self-identified their roles and identified others as being a part of the diagnostic team. Participants differentiated identity of diagnostic teamwork for those who are involved in diagnostic decision-making, as opposed to interactions that involve the sharing of diagnostically-relevant information without contributing to decision-making. The most identified roles included the attending physician, fellow, nurse practitioner, resident, and interns. These results were found across nearly every participant, with some variances in mentioning other roles. Other roles described in no particular order included: consulting services, medical students, dietary staff, radiologists, nutritionists, pharmacists, pathologists, physical therapists, physician assistants, and respiratory therapists. These roles were described as contributing to diagnostic decision-making under rare circumstances, beyond simply providing diagnostic-relevant information, despite regular significant contributions towards treatment decision-making. More involved contributions of diagnostic decision-making or reasoning coincided with higher team identification for the four roles of attending physician, fellow, resident, and nurse practitioner.

3.3.3 Finding 3: Nurses

The theme of nursing team identity was varied and less clear. In summary, nurses were described to participate in the history-taking and significantly involved in day-to-day patient care, but a few additionally described nurses as involved in diagnostic decision-making.

Participants describe nurses as sources of information without always providing significant diagnostic input. Nurses were described as most regularly acting as intermediaries

between the patients with patient families and the diagnostician members of the diagnostic team. The role of nursing was emphasized as critically important to MICU functioning, with day-to-day functions including the sharing of information relative to the diagnosis, as well as important and regular roles in treatment. Further, in some situations, they share information crucial to reach the correct diagnosis due to high levels of involvement with regular patient care, including information not captured by other MICU providers:

Resident: *"I think that you gather information from the Nurses at the bedside, you gather information from Respiratory Therapy at the bedside, you'll gather information from the Family members, and that's - you're not necessarily, exactly going to discuss your specific diagnosis with every one of those people, but you're gathering pieces of information to help you figure out stuff."*

Attending, when describing who is a part of the diagnostic team: *"Nurses. They may not - a Nurse may not have the entire story, necessarily, but they may know a very important piece, especially like in cross coverage, or they may be present for Family interaction where they have important information about the dynamics in the Family, or concerns that the Family has. So they're hugely important sources of information for - the patient experience and the family experience as well - and sometimes they will discover things about what the patient said or how the patient was treating them and how that wasn't relayed to us based on those interactions, and that could be a clue to chase down."*

Others suggested that nurses more regularly contribute to diagnosing patients by providing their input, as opposed to simply providing information. In some instances, the diagnosis may be concluded by the nurse as they have witnessed a pathognomonic event that finalizes a diagnosis. In regular care, nurses may be sought after for their perspectives on diagnostic possibilities in order to supplement or assist the primary diagnosticians in completing a diagnosis:

Fellow, describing when they ask others for diagnostic perspective: *“I will also say that [in] this unit the Nurses play a big role in that as well, they've seen a lot and they're very experienced and they will give a lot of ideas on what they think it might be. They want to know what we're thinking and might be, too, so I think they actually play a much bigger role in this unit than in a lot of other units... in that diagnostic process.”*

Attending: *“...during the course of the patient's stay, every day there are new additional diagnoses made, that's - some of that input comes from other members of the patient care team: the nurses who are there by the patient who've made the initial observation, the nurse may be the first person to have observed the seizure, and then we order the E.G. and confirm that it was a seizure... So the support personnel contribute to a lot of the data, but initially, when we get to know the patient, it's exclusively that Intern or Resident who gathers all of the data and summarizes it.”*

Nurse identity as a part of the diagnostic team was not clear, as some providers perceived nurses as a part of the diagnostic team while others suggested they were not. Compared to a resident who described nurses as not contributing to diagnostic discussions, another resident suggested nurses are indeed involved in diagnostic discussions in which their opinions are sought after and offered, beyond simply sharing and updating information. Additionally, primary diagnosticians who are not experienced in the MICU setting, such as residents with emergency medicine backgrounds, may further seek nursing input for diagnoses. All together, these recognitions of diagnostic contributions correlated with more frequent identifications for nurses being a part of the diagnostic team within single participants. Whereas, the majority of participants did not mention nurses as part of the diagnostic team, some made the connection for diagnostic contributions and team identity:

Resident: *“Nursing is actually more involved in the process here than they are probably on other floors, often the Nurses kind of suggest potential things to kind of see what our*

thoughts are about it. And so I think, especially here in the ICU, the Nurses are part of the team.”

Resident: “I mean, a lot of times the Nurses actually come up with some really great ideas. Actually, not just some of the time; most of the time they do. So it's actually really good to get their feedback. And especially since as a Resident, I'm only rotating like one month out of the year and for like 3 months, my entire Resident career; three months out three - of my entire year, so critical care is not something I do on a daily basis and so something that I enjoy, and something I feel I'm getting better at with time. But it's definitely not my wheel house, whereas, the Nurses who are here day in and day out and this is literally like all they do, and so they see a lot more of what's going on, and they can actually help clue me in, like ‘Hey do you want to check this? Do you want to think about that?’.”

3.3.4 Finding 4: Patients and Patient Family

Patients and patient families represent another area of unclear provider perceptions regarding team identity and diagnostic decision-making contributions. Only one participant identified patients as explicitly being a part of the diagnostic team, describing that it is beneficial for team effectiveness to have diagnostic input from everyone, including the patient:

Fellow: “But a lot of times, if we have a patient on the team, it's good to have everyone's input who's on that team.”

While only one participant described the patient as a part of the diagnostic team, several participants mentioned the patient as important sources of information relevant to diagnosis. Yet, a limiting factor of such information sharing was described as patient inability to provide a history. As a solution to limited patient capabilities, participants identified patient family and friends as facilitating HPI collection and, therefore, contributing information relevant to the diagnosis. No participants described the patient family as a part of the diagnostic team:

Attending, describing how a patient is diagnosed in the MICU: *“You know, I think we start with the history. The history sometimes is abbreviated because the patients are in a situation where they can't give a lot of history so we look for other sources, so from family members, or friends, or significant others...”*

Attending: *“Family also provides important information with regard to diagnosis – [with] a lot of our patients, we have to get collateral history. And the family of the patients provides the history.”*

3.3.5 Finding 5: Other Roles

One perspective regarding team identify fell outside of the realms of providers and the patient. When a resident was asked who they consider part of the diagnostic team, the participant described how their physician sibling may help them under situations of diagnostic uncertainty over a phone call. The assistance occurs with patient anonymity and yields diagnostic input, despite the participant reaffirming the family member as not a member of the diagnostic team. However, the question of perceived team identity made them consider their sibling, indicating recognition of their contributions, but differentiation from the ‘official’ team:

Resident: *“Um, Fellows, Consults, Attendings... In the off chance I could always talk with - I mean, my [sibling] is a doctor, so some questions, I can just pick up the phone and say 'what do you think of this?' But I rarely do it, and not in this situation, no. And it would be confidential, it would be - the patient's name would not be revealed – but if the patient presents with something, maybe, get ideas from my brother. But otherwise, I rarely do it.”*

3.4 Theme 3: Diagnostic Contributions in the Clinic Backstage

In addition to regular teamwork, a common theme emerged surrounding the collaboration of diagnostic contributions from those not directly assigned to a patient’s care. For example, a resident will communicate with the attending physician and fellow co-assigned to a patient’s diagnosis and treatment, but the resident also may confer with colleagues within the

clinic who are not assigned to the patient in order to obtain their perspective. This theme can be modeled to the diagnostic procedural steps with role involvement and examining while such interactions occur.

3.4.1 Finding 1: The MICU Diagnostic Process

Description of the diagnostic process was obtained through initial discussions with the study contact person, shadowing a morning rounds, shadowing a patient triage with admission, and walk-through descriptions during interviews of how patients typically are diagnosed in the MICU. To note, participants acknowledged that practically no patient is typical in the MICU. However, this concept was included by intention with the interest of modeling and capturing the themes of how a diagnosis changes with varying patient presentations or provider characteristics.

The diagnostic case begins as a fellow receives a triage call from another location that is either an in-house floor (emergency department, oncology floor, surgical floor, medical floor, or other floor), or an outside facility. If the patient is in-house and it is not certain if they meet the ICU admission criteria, the Fellow may first see the patient in person to determine if they warrant admission. They may also invite the resident or nurse practitioner to accompany them. The fellow hears the patient story and either accepts the patient to an open bed, or declines because the MICU is full or the patient may be better served at another ICU, such as the cardiovascular or surgical ICU.

After approving the patient admission request, the patient is assigned by the fellow to a nurse practitioner or a resident. The choice is based on random availability and equal distribution of patients between roles. The resident or nurse practitioner is provided the patient case from the fellow, with levels of information varying from a significant amount (coming from in-house or having previously been admitted) to very little (if very little or no information is given prior to admission, they have no history at this facility, or if no patient family is present to assist). When assigned a patient, the resident or nurse practitioner reviews this previous information,

which may include previous care done elsewhere (thus beginning the collection of medical history) and puts in preliminary orders before they arrive. In seeking additional information, they may look at past medical records, try to reach the patient family, or try to reach the local doctor. If no information is available ahead of time, the resident or nurse practitioner will begin with a pre-arrival packet (health management plan, progress notes, and vitals) to sift through and get up to date. They will then assess the patient and add all vitals to date, including laboratory and image tests. Laboratory and imaging orders may be placed before or during the patient stay, and typically are ordered by the resident and nurse practitioner.

Incoming patients present with chief complaints, for which the fellow, resident, and/or nurse practitioner may come up with a differential diagnosis consisting of a list of diagnoses that are associated with the chief complaint before the patient is admitted. Occasionally, the fellow may provide the resident or nurse practitioner with a preliminary diagnosis based on the triage call.

Upon patient arrival and admission, a history and physical information collection (HPI) is performed. This is performed by the resident or nurse practitioner alone, or with the fellow accompanying them. Nursing does not participate in the initial history or physical. The fellow typically collects their own HPI separately. In addition, the accompaniment of the fellow or attending physician may begin at an earlier stage for more severe patient cases, such as collecting the HPI and beginning treatment upon admission. Based on the list of signs and symptoms associated with each diagnosis, the resident or nurse practitioner guide their history-taking to move things up or down the list and guide their physical examination. Sometimes, this data alone permits determination of the most likely diagnosis. Otherwise, further diagnostic studies may be needed to isolate a single diagnosis from the differential diagnoses, or preliminary treatment is needed to stabilize the patient. Sometimes, conflicting diagnoses move up the list, and in the meantime, they start interventions that will help while they attempt to sort out the diagnosis. The resident or nurse practitioner writes the primary daily progress notes and is the "primary push person" putting in the daily orders. The attending may involve himself or

herself earlier on if the patient case is very severe. Nurse practitioners may perform their HPI alone, whereas, the resident may be accompanied by the fellow on a more regular basis.

Regardless, the fellow will complete their own HPI during or after the resident's HPI.

After collecting the HPI, the nurse practitioner or resident will next typically talk with the fellow in an event called "staffing the patient". This team interaction consists of the resident or nurse practitioner providing the fellow with a synopsis of what information they have collected, any diagnoses, and their plan of care and management. In addition, the fellow will compare their HPI with the resident's or nurse practitioner's HPI. A discussion occurs with back and forth input as a form of supervision and education. This staffing the patient is completed at some point for every patient admitted, and is done once every day including morning rounds, to discuss what they need or do not need to do. As more information is obtained throughout the day, the initial assessment is amended and new plans are made.

The ordering of further laboratories, exams and imaging will be performed and completed throughout care by being ordered before admission or during patient stay, and are typically ordered by the resident and nurse practitioner. The resident or nurse practitioner may order consulting services which consists of five or six different teams with sub-specialized knowledge within different areas. These specialties were described to include brain, lungs, abdomen, neurology, and surgery. Calling 'standard' consulting includes examples, such as gastrointestinal bleeds or blood infections. Under certain circumstances, the resident or nurse practitioner will confer with the fellow if they are uncertain, or under other times they will confer with the attending physician.

As more information is obtained throughout the day, the initial assessment is amended and new plans are made. Through an iterative process, a semi-final diagnosis is reached through differential diagnosis. This is communicated to the attending physician, who may sign off on the final diagnosis or disagree and suggest alternatives to explore. In addition, the cases will be presented to the attending during morning rounds, through pages at night, if simple enough, or require interventions at odd hours.

Attending physicians will hear about patients the day they are seen, or the following morning at rounds. In the beginning of the year, in July through September, the attending physicians will perform a more supervisory role in detail over the new providers. As the year progresses, less oversight is needed and diagnoses do not significantly change upon presenting to the attending physicians.

The resident or nurse practitioner acts as the primary contact and decision-maker regarding diagnostic tests and the collection of the HPI. The attending physician ultimately is responsible for the patient and has the final say regarding diagnosis and treatment. Attending physicians typically join for the morning rounds when residents present, while fellows supplement for the more severe patients and assist the residents in preparation before they present at rounds. Attending physicians are on call at night, but they are typically not in-house and not called for every case. For instance, they may call if a patient will be put on special treatment extra corporeal membrane oxygenation. Attending physicians play a supervisory and educational role with the final say regarding diagnosis, with an educational role being more significant towards the resident. Residents gain more trust and independence from the attending physician as they transition from interns to more experienced residents.

The pulmonary critical care fellow acts as a mid-level between being a resident and being an attending physician. Compared to residents, the fellows may focus on “big picture items” including the ventilator and shock while residents take care of “general care” including glucose levels. There are two fellows on the day team who do rounds with the team in the morning. After triaging, the fellow informs the charge nurse about the incoming admission.

Medical students typically work with the fellow and help collect the HPI or collect their own as experience. Residents may talk through a differential with them and ask what they should do before seeing patients. They also may attend and assist the presentation of rounds.

Shift changes among providers were described to occur from day to night as on-call person attending physician comes on at 5:00 PM and a night intern begins a night shift around 7:00 PM when handoffs occur. During the day, the attending physician may leave the ICU for a

while to attend meetings or work in their offices for academic work. Some walk around the MICU at certain times such as 4:30 PM to learn new admissions since last discussion with providers. If interns collect the HPI, they will run it by the resident and then the fellow. For overnight patients, they will be seen by an overnight resident, who will collect their HPI, discuss with the overnight fellow as they discuss the patient case and start management, followed by presentation to the attending physician in the morning. The fellow was described as functioning as the attending physician in a similar role for overnights. This is compared to the day, when the attending physician is still in-house and patient cases are presented sooner. During the day, the resident may not talk to the fellow in between the attending physician, taking their information straight to the attending in a same format with the fellow: “here's what I know, here's what I think is going on, and here's what I would like to do”. The attending physician is either found in the MICU or paged to request their attendance.

3.4.2 Finding 2: Diagnostic Input from Perspective Input or “Bouncing Ideas”

A significant amount of teamwork occurs when providers ask for and receive help with diagnostic cases, as well as for supervision that occurs from more experienced roles. Assistance with diagnostic uncertainty was described as part of the regular diagnostic process as well as occurring outside of the formal, procedural lines consisting of the attending physician, fellow, resident, and nurse practitioner. Interactions were described consisting of requested and provided diagnostic help with teamwork occurring through the same and different roles. For more complex and less straightforward diagnoses, clinic backstage communication and formal consulting services are used to evaluate diagnostic plans and conclusions. When confronted with uncertainty, providers described various solution strategies, such as conferring with those formally involved with the diagnostic care including the hierarchy, formally requesting consulting services, and informally conferring with colleagues not directly involved nor assigned to the present patient case. This backstage teamwork was framed as occurring within informal and formal contexts, including the use of a hierarchy that encourages open discussion. A setting

was described in which open collaboration is encouraged. As previously described, contributions from every MICU team member were promoted for collaboration.

The typical interactions described as diagnostic teamwork included the attending physician in a supervisory and educational role towards the resident and fellow in particular, as well as the rest of the MICU team. Participants described such events as back-and-forth discussions where diagnostic considerations are questioned similar to debating. This was suggested to play an important role in making a diagnosis, with benefits towards making the correct diagnosis. Attending physicians, who review these discussions, ask the team to defend their conclusions and consider alternatives. This was described to occur for supervisory and educational reasons in learning how to successfully 'sell' one's conclusions to other members. Further, regular reviews by the more experienced attending physician permits the primary points of care, the resident or nurse practitioner, to obtain experience with greater safety through supervision. Further, by asking the diagnosticians to consider alternatives, hypothetical case scenarios are described for which they are asked for comparison with educational benefit. Results demonstrate that the supervision occurs for the present case, while education occurs for the present and future cases with similar or dissimilar presentations:

Fellow: "When the Attending comes in, a lot of times it's after we've done the initial workup and have a working diagnosis and they can come in and say 'Did you think of this? Did you think of that? You know, I agree with this, or I disagree and here's why and here's what you should do to further investigate', so it kind of put all of our heads together."

Attending, describing the back-and-forth discussion occurring with residents and fellows: "There's varying levels of experience and there's varying levels of ability to defend their position, but they might have noticed things. They might have made correct diagnoses but they may not have communicated it in a way to me that has sold me on it. So I'll say 'So you think it's pneumonia. I want you to sell me on why it's pneumonia.' So I'll ask for evidence. I'll also ask to - for them to consider alternative diagnoses. 'Could it be pulmonary embolism instead of pneumonia? Why so? Why not? How would you order these possibilities?'"

Along with attending physicians, consulting services also contribute to diagnostic inputs by providing their perspectives on what diagnoses may be considered or to confirm the conclusions reached by the diagnosticians. Consulting services are called in situations of diagnostic certainty and uncertainty: providers may be unsure how to diagnose certain conditions and request expertise, or they may be confident in that a certain condition is outside their area of expertise or what they regularly see in patient presentations. The input gained from consulting services is then combined with the perspectives of the diagnostic team, who deliberate the opinion of the specialized consultants:

Resident: *"If you're interpreting the CAT scan of somebody who has Shortness of Breath and CHF, and whatever, whatever, you're going to have Radiology who's going to give you what they think based on the images, and then you'll discuss with the Attending, with the Fellow, and maybe co-Residents, kind of figuring out what your interpretation of what that is: Yes it is pneumonia, yes, this is interstitial lung disease. Yes this is that."*

Fellow, describing when consulting help with diagnoses: *"It depends on the situation and what we think is going on, and what our differential is or what based on the data, if we think we need the opinion of another specialty who is more knowledgeable about a topic or has the ability to do certain procedures that we're not capable of doing, and so, like kidney doctors doing dialysis, heart doctors doing heart caths, GI doctors doing the scopes, so - and obviously if we think our diagnosis or our differential is honing in on a diagnosis that is among a certain specialty, we tend to get them involved."*

Other results described team-members helping each other in an informal context that occurs in the clinical backstage to assist the diagnosis of present patient cases. For assistance with present cases, they may confer with team members who are formally assigned to a patient's case or those who are not formally assigned to a patient case, but are nearby in the MICU. Diagnosticians may confer with their colleagues of the same role or other roles. MICU providers confer, not just with higher hierarchical roles such as the attending physician, but with

those not assigned to the patient: their colleagues, other-role team members, and even their own family. All together, these interactions were described as occurring informally and without documentation or credit:

Overall, participants from each interviewed role suggested that they find these interactions helpful in obtaining another's viewpoint for confirmation or to consider things not yet considered. The most common reason was to obtain input whether in asking someone for their opinion of their logic, advice on what to do, or to simply practice saying things without actually seeking someone else's opinion. However, less task-oriented communications involved sharing interesting cases that providers considered worthy of sharing within the MICU or at conferences. They may confer when feeling uncertainty about a diagnosis by requesting a review of conclusions that a diagnosis is true or help deriving what diagnostic tests to perform.

Nurse Practitioner, when asked when they collaborate with other nurse practitioners: *"I would say, definitely on a more of a 'off the record type' base, yeah. I mean, definitely running ideas, running differential diagnoses to the other Nurse Practitioner - who's working here on my shift - yeah I'll run things by them, but that's more of an informal setting than formal setting... just kind of 'this is what's going on'... like what do you think? What other thoughts would I maybe be missing? Or do you have any helpful pointers?' like things like that. "*

Resident, demonstrating that occasionally they'll confer with colleagues: *"I have discussion[s] with other Residents on the team as well... if there's a particularly interesting or difficult patient in the sense that it's not really clear what's going on, we can talk amongst ourselves even though they're not directly involved with the care for that patient."*

Other reasons for which diagnosticians seek out other perspectives include significant rarity in patient illness, as they may not feel confident due to a lack of experience in diagnosis of a particular illness. Another reason is the utility in gaining the perspective of someone who has no knowledge of the current patient case. Therefore, the provider performs a walkthrough

review in order to describe the case to someone who has 'fresh eyes' and is freer from any preconceived notions of which the original diagnostician is unaware:

Attending, asked when they confer to others for their opinion: *"So sometimes I see things that are rare, or sometimes when the data that I have does not make sense. And so I would ask other Attendings for their opinion. Sometimes I will also ask for other opinions so you can get a kind of fresh set of eyes to look at the case, and I find that to be helpful. And sometimes you [get] kind of too involved in the case and might be missing something. So sometimes I will ask someone to review the case formally, as well."*

Additionally, when they are not as experienced as others within their same role, providers new to the ICU, as a part of their recently-finished training, may also seek feedback. By engaging with other providers including colleagues, learning may be facilitated in a supportive format. Another reason to request opinions is due to the limited length of a short-term rotation in the MICU compared to more familiar backgrounds in other areas of practice, such as emergency medicine for the residents. For these instances, the providers with short rotations described working with more roles than simply working with their colleagues. Further, the assistance may not be actively sought after but offered to maintain role differences in a non-challenging format, similar to addressing a room:

Resident: *...As a Resident, I'm only rotating like one month out of the year and for like 3 months, my entire Resident career; three months out three - of my entire year, so critical care is not something I do on a daily basis and so something that I enjoy, and something I feel I'm getting better at with time. But, it's definitely not my wheel house, whereas, the Nurses who are here day in and day out and this is literally like all they do, and so they see a lot more of what's going on, and they can actually help clue me in, like 'Hey do you want to check this? Do you want to think about that?'"*

However, in comparison to all the presented themes regarding when MICU providers may refer to the attending, consulting, and roles not involved directly with the patient's care, some participants described why they alternatively refer to their colleagues less often. This is in contradiction with most participant statements and occurs due to perceived issues of inaccessibility or just that they naturally refer to other roles more than their colleagues, whether part of the regular diagnostic team or not directly involved in the patient's care. Not collaborating with the same role on the other MICU team also was described as not occurring due to accessibility:

Fellow, describing why they typically don't refer with their colleagues: *"Yeah, less often with other Fellows in real time, because there's only one Fellow on call at a time."*

Resident, when asked if they collaborate with other Residents about diagnosis: *"So I think yes, and - because of how the workflow works in the ICU, we're often covering for each other too. So on our call days it's kind of like a 20 hour shift, and then we go home like around noon kind of on our post-call day. And so actually, a lot of things kind of happen where we're covering for someone who the other Resident admitted, and so that's where most of the shared teamwork does - I don't necessarily know if we discuss that much with a Resident when we're also there. Some we probably would because they're on our team, but not talking with Residents on the other team, much at least."*

And they also have other sources not yet considered in literature, such as provider family that have experience in medicine who are formally involved with the patient's care:

Resident, identifying who they consider part of the diagnostic team: *"Um, Fellows, Consults, Attendings... In the off chance I could always talk with - I mean, my [sibling] is a doctor, so some questions, I can just pick up the phone and say 'what do you think of this?' But I rarely do it, and not in this situation, no. And it would be confidential, it would be - the patient's name would not be revealed - but if the patient presents with something, maybe, get ideas from my brother. But otherwise, I rarely do it."*

3.5 Theme 4: Characteristics Change How Teams (and Individuals) Make a Diagnosis

Findings were collected regarding diagnostic teamwork, specifically when teamwork occurs more or when teamwork occurs less (i.e. individualized work). Characteristics found to change the diagnostic process include varying patient presentation cases and provider situations. In summary, characteristics were found to increase or decrease teamwork under different situations. Severity of illness promotes earlier involvement with increased teamwork while diagnostic uncertainty may or may not promote teamwork. In addition, diagnostic disagreements were described to occur and solutions were collected in interviews.

3.5.1 Finding 1: Severity of Illness and Complexity

Severity of illness changes the approach to care, including increased requesting of a diagnostic input. Reasons for uncertainty as previously discussed related to the seeking of another team member's input, and included utilization of consulting services, earlier involvement of the attending physician, and increased teamwork in task completion such as the fellow and resident collecting the HPI together. However, practices also changes individualized practice outside of teamwork dependent on the level of severity.

For less severe cases, the diagnosis may be streamlined and involve less teamwork. These presentations are clear based on procedure and experience, but complexity is a compounding factor as less complex patients also streamline the process of diagnosis. With increasing complexity in tandem with severity of illness, the need for teamwork increases as more providers are brought on board to handle the varying problems that require focus and expertise by bringing consultant services and more diagnostic team inputs on-board:

Nurse Practitioner, being asked if severity of illness changes who they work with to make a diagnosis: *"I think their severity does play a big role on that. We have certain diagnoses that we're able to manage a lot easier than certain others. For example, there are certain frequent flyer kinds of patients that we, or - certain patients that we have a protocol that we can go by, so we don't really have to bounce the ideas off because the protocol's there and we just know what*

to do. *But with the more complex people, the more organ systems that are affected, probably the more teamwork is important. The more critical the patient is, yeah.*”

Resident: *“It sounds like the collaboration happens most when the patient is more sick - I mean everybody in critical care is pretty sick, [Laughter] - but there is still a spectrum, like those that are more like the psychiatric overdose case, or the alcoholic intoxication, it's a little more clear cut, a little less complex, and so, therefore, it's a lot easier for everyone to know what's already going on with more certainty, without having to do as much of that collaboration. Whereas,[when] the patient is actually coding or actively crashing and heading towards coding, then, honestly, everybody is in the room, we're exchanging ideas really freely, and we're all working together pretty quickly to prevent the situation from possibly getting worse. So I think the more with, the increasing acuity of sickness of the patient, there is increasing collaboration.”*

Alternatively, when increased severity of illness does not elicit teamwork is under high severity combined with patient or patient family preferences. By involving the patient family in decision-making, judgments may be made regarding the discontinuation of more refined diagnostic procedures or treatment options. Considerations may include whether it is worthwhile to know and understand the risks involved in pursuing further options on quality of life:

Resident: *“The more severe the patient's condition is, there's a chance of backing off on invasive tools, like how far you will ever go is a care discussion. We ask family 'how far do you want us to push forward?' if it's so severe, like if there's a 90 year old patient, would they have the quality of life improve? So 'should we order more testing?' is something we would discuss with the family, if we want to back off on the pushing. Not [to} find a diagnosis sometimes, is what I give [a] person who has a mass, bronchial mass, and an older patient who is bleeding, do we want - and we know it's not treatable - do we need to pursue that diagnosis if it's cancer, or not? ...if we know ahead of time the family doesn't want for the patient, if the patient doesn't want further treatment, then we don't need to bring in multiple teams.”*

3.5.2 Finding 2: Uncertainty

Participants emphasized that uncertainty plays a significant role in making a diagnosis. Further, uncertainty is inherently a part of intensive care practice as a whole and for diagnosis of MICU patients. As described in previous sections, uncertainty corresponds to increasing complexity and increasing severity of illness, but not in all circumstances. When confronted with uncertainty, providers described various strategies to uncertainty. Uncertainty was suggested to vary with conditions, wherein rare or unusual presentations are more likely to cause MICU providers to seek out another's input. Various solutions were suggested to combat diagnostic uncertainty.

One strategy involved conferring with MICU providers as a whole, either those directly involved in the patient case as well as those not directly involved. Such MICU providers may include the primary diagnosticians and consulting services. Further, the supportive environment is facilitated by the attending physician in a form of authority as well as being facilitated by other MICU team members, either as peers or different roles. The benefits from generating team conversations were previously discussed in results, but in review these discussions can help facilitate greater considerations of options to pursue in the next diagnostic steps:

Attending, upon describing how they handle diagnostic uncertainty: *"Yep, so there are a few different things that I do. The first is I try and - so this is the advice I give to a lot of junior people when they are becoming an Attending for the first time: ...harness the intellectual capital of the team, because there's a lot of horsepower in there'."*

Resident: *"Like I think if you're, kind of like lost in the woods, that's when you would bring your Consultants in, so that's when you would maybe talk to Renal or talk to Cardiology, and so then you would bring your Consultants in and they would help as well. They would be like another piece of the puzzle. And that's when you then go for maybe more specific, maybe get more invasive like biopsy-testing and those kinds of things."*

As opposed to seeking the work and input of other providers, some MICU diagnosticians instead independently obtain more information to combat uncertainty. Yet, a balance is necessary, as too much information may produce unnecessary complexity in making a diagnosis and may not be necessary as reflection may suffice to deal with uncertainty. In addition, having sufficient time may permit MICU providers to choose to seek more information and figure things out autonomously. However, another factor with time is simply having enough time to consider the diagnoses, and more information may not even be required or helpful.

Fellow: *"I try to gather more information if I need anything. The more information you have - it's a certain point: too much information can make everything more difficult, too hard to work through. But in general, if you're uncertain, if you try to order more tests or gather more information in any way that may help lead you and put you to a certain diagnosis. ... With certain things, you'll figure out with more time. And also you just try to organize your thoughts. I think that's the biggest thing is to try to really organize your thoughts."*

Resident: *"I think there's always uncertainty and that's why we have a broad list of things that we think it is and then we order tests and get imaging and stuff to narrow it down, but I don't think right away we just know."*

However, some participants suggested that in the end, some diagnoses are never known, and ultimately necessitate a judgment call. This is influenced by the iteratively changing nature of diagnosis, which determines early treatment after stabilization and may be refined as the treatment becomes insufficient. In addition, less straightforward diagnoses may correspond with more of a judgment call when data does not support any significant conclusions:

Attending, describing how a patient is diagnosed: *"Some diagnoses are straightforward, others are more of a judgment call in a sense that you might have conflicting data or you might have data that doesn't necessarily lead to a full diagnosis, but kind of gives you more than one, so you prioritize which one you think is more likely... For example if you have someone who comes in with, let's say, fever, elevated White Blood Count, chest X-ray that shows a*

consultation, then you would call pneumonia. But sometimes things are not as straightforward and unless the case is a kind of - I guess some of it could be like a hunch, like what does my gut-feeling tell me. Sometimes you know, you don't have - either you don't have enough data or the data doesn't fall in the same basket. And when that's the case you follow maybe your instinct."

3.5.3 Finding 3: Disagreements

Disagreements may regularly arise surrounding differential and final diagnoses. If not initially solved quickly, diagnostic disagreements are usually solved by raising conflicting viewpoints with superiors and may or may not be documented. Diagnostic disagreements were described as a positive, healthy part of medicine that is an inherent aspect of eliminating, defending, and finalizing a correct differential diagnosis. None presented disagreements in a negative light, such as an annoyance or frustration. Examples of disagreements about diagnosis include differences that occur among the roles, such as the resident and fellow or nurse practitioner and fellow.

Attending: "One of the important things about that information flow, I would say, is it's really important to have a healthy level of skepticism about the nature of those diagnoses. And so I'd say one of the commonest ones that comes up, is patients are referred to us with a diagnosis of pneumonia and it's not getting better, and our job is to revisit the idea that it is pneumonia at all. It might be something else that looks like pneumonia on a chest radiograph that maybe makes a patient short of breath, but it is something that's not pneumonia. So we don't turn down this information stream, and there's gold there, but it's also our job not to take it all at face value and to re-visit the diagnoses because that's part of why they're coming to us."

Some suggested disagreements may be resolved using debate as a normal part of care. A discussion occurs in the form of debates with logic and reasoning supporting and disproving logical connections. The majority of diagnostic disagreements were described to be resolved

through this approach and resolved amicably. Further, these disagreements appear to arise out of normal care and being explicitly asked, such as the educational challenges provided by the attending physician:

Nurse Practitioner, describing how a patient is typically diagnosed: *"I will come up with my own diagnosis and share it with others who may also agree or disagree with what I've come up with, so usually the symptoms that people present with can be symptoms of multiple things, so you kind of have to narrow things down bit by bit by ordering more tests that will then lead you further down the path. So it's kind of a stepwise action, actually, that will go through multiple people. And then as a team we usually pretty much come up with the diagnosis, the ultimate one. And that may change over days."*

Resident: *"I think the more typical thing that happens is the Fellow knows a patient is coming, and they say the patient is coming in with this diagnosis, and then you say "ok, well that's sounds good, sounds like this is what we're going to do for them". And then, I think we'll go see the patient, and depending on whether or not when we actually see the patient we agree with what we thought was the diagnosis initially, we'll go back to the Fellow and say "here's what I think is actually going on" and they may or may not agree with you."*

Some disagreements may be resolved by involving a superior role, which would be the attending physician within the MICU setting. In addition to possessing legal responsibility for patient care and for all team actions, the attending physician was described as having the final say for diagnoses. This option was described as only occurring after being unable to reach a consensus among roles, such that they feel it is necessary to check with attending physician because it is important enough. This interaction was also described to regularly be resolved amicably:

Nurse Practitioner, when asked to elaborate on how they handle diagnostic disagreements that arise: *"Usually, take it to the Attending. Ultimately, the Attending is kind the person that will give the final thoughts on that. So there are a lot of times where I will disagree*

with the Fellow or disagree with the Resident, and we will kind of make our cases and if we can't come up with a solution, we'll go to the Attending and just say 'this is both of our thoughts' and the Attending will usually be the one to tell us which direction to go."

However, the attending physician may also experience diagnostic disagreements. Disagreements may arise between the primary diagnosticians and requested consulting services, representing a disagreement between the MICU primary team and consultants. Such conflicting viewpoints may resolve amicably, involve a sought after third perspective from another consulting service, or not be resolved given the inherent decision authority held by the MICU providers, as they requested the advice of consulting and have the authority to do with it what they decide. Therefore, disagreements were described as not necessarily requiring resolution:

Resident, describing disagreements that occur between the primary team and consultants, and between primary team members: *"So we're the primary team, and we're asking them for recommendations, and so we have the recommendations and decide what to do with them. So, ultimately, we have the last say in what happens for the patient. So it doesn't really matter if they don't agree with each other, like we have to take that information and decide what to do with it."*

Attending, describing when they disagree with consulting services: *"If I feel very strongly about something, and I really think I'm right or I think that the downside might be wrong - is too high to not do the procedure, if in that case, that case I may not involve a third party. That's a disagreement between me and someone else, which is fine, and not everyone has to think like I do. And they might be right, but sometimes we have to sort that out."*

3.6 Theme 5: Sources of Error Through Diagnostic Teams

Without being explicitly asked in interviews, participants also provided perspectives on teamwork or the diagnostic process. Errors were perceived to occur around failures of teams or

parts of the diagnostic process. In addition, some MICU providers presented awareness that individuals may be prone to cognitive error in diagnosis.

3.6.1 Finding 1: Errors from Teamwork

As a minimum within the diagnostic process in the MICU, information is simply shared with minimal team decision-making. At a maximum, input or perspective is provided at each diagnostic state. For each level of decision-making involved, there exists a potential for a loss in information sharing. The result of such lost information is either a complete loss of information that may or not be crucial to reach the correct diagnosis, or extra work performed to recapture the lost information such as revisiting notes if aware of the error. With two parties involved, a sharer and receiver, there are two ways in which diagnostic information may be lost. First, is a failure to share crucial information in which the information is not shared at all or is emphasized in a manner that detracts from the intended meaning. Examples include diagnostic team interactions, such as the fellow and nurse practitioner, and resident and consulting services:

Nurse Practitioner, describing how patients are diagnosed in the MICU: *“The Fellows always receive the initial call with the information. And then I get report from the Fellow, so it's - there are multiple people involved in the call process. And it's unfortunate because sometimes information gets kind of left out along the way, it's like a game of telephone, initially. And every time that telephone game gets played, a little bit of information is lost. So sometimes you have to go back through paperwork, old records from the offsite hospital, and gather as much information as you can, or from the Emergency Room, and try to fill in the blanks where they may be.”*

Attending: *“That's where, by and large, the system works well, because the junior person reports to the - the intern reports to the Resident, but the Intern and Resident report to the Fellow, they all report to me. So, usually, these things are digested in such a way that there aren't major gaps or situations where people are operating beyond their ability, but it's always possible. Could be that someone of us has [a] key piece of information from the Family member*

and doesn't communicate it, *or perhaps communicates the essence of the Consult question to the Consulting service in a way that is not exactly what we're looking for, and we lose time because the Consult question wasn't accurately communicated to the Consulting service, they don't know exactly what we're concerned about.*"

The second side of failing to share information necessary to make a diagnosis, is a failure to adequately elicit or listen to crucial information. This may occur due to being rushed with urgency or high patient workloads, not feeling the need to consider more information, and the need of attending physicians to balance multiple roles in work, such as education, research, and clinical practice. Research is perhaps most unique to the attending physician, however, the first two considerations may occur for other team members:

Attending, describing the potential for error in the MICU: *"If you fail to carefully listen or provide the data, and if you're in a hurry and if you wanted to staff 12 patients in one hour, you're just going to cut off the Resident with information and you are just going to take the minimum glaring information and close off your diagnosis and keep walking. So the - how hurried you are, or how busy you are, can affect some of the diagnostic decision-making in the group situations, because you have to balance between teaching, making the diagnosis, writing your notes, and moving forward."*

3.6.2 Finding 2: Errors from Diagnosis

Along with errors occurring due to teamwork, errors also were perceived to occur due to individual biases. An inherent part of ICU care is that patients are severely ill, which frequently results in unconscious or intubated patients. Due to patient status, the patients may be unable to assist in the completion of patient history. Therefore, diagnosticians pursue alternate rounds, if available to supplement whatever patient history is received upon admission. Even if present, patient families may not entirely be able to provide the same information the patient is unable to share.

Attending, describing how patients are diagnosed in the MICU: *“The history sometimes is abbreviated because the patients are in a situation where they can't give a lot of history, so we look for other sources, so from family members, or friends, or significant others, and I would say frequently one of the limitations of the diagnostic process is not having very good history.”*

Finally, another perceived source of error in diagnosis may include overconfidence. By being too confident, diagnosticians may not reach out to others for help, recognize their inabilities, and possibly perceive themselves as infallible. Overconfidence may cause a lack of due consideration towards diagnostic alternatives through anchoring or confirmation bias, whereas, someone who is open to and seeks other's perspectives, may be more likely to cause less error and reach the correct diagnosis:

Nurse Practitioner: *“I am a very uncertain person, so I bounce my ideas off of other people all of the time. People who are [a] little more confident might be less - more reluctant to do so. They feel like they should just run the show..._People that are too confident and come up with a diagnosis can get tunnel vision and have a difficult time thinking that it could be something else. So it's good to be able to question yourself a little bit, so that you're flexible in thinking 'well maybe I'm thinking in the wrong direction, and I should steer in this direction instead.’”*

CHAPTER 4

DISCUSSION

4.1 Summary of Discussion

The following sections explore insights from this study and discuss implications of teamwork on diagnosis and diagnostic errors. Five main themes from our findings are discussed in this chapter, briefly summarized below:

Theme 1: Teamwork in Diagnosis is Regular, Important, and Flexibly Defined (in section 4.2)

Providers perceive diagnostic teamwork as an important and regular occurrence, but with ambiguous boundaries for patient treatment and diagnosis;

Theme 2: Team Identity Corresponds with Diagnostic Contributions (in section 4.3)

Perceptions of team identity and diagnostic contributions of nurses, patients, patient families, and others not assigned to a patient's care;

Theme 3: Diagnostic Contributions in the Clinic Backstage (in section 4.4)

Recognition and significance of the diagnostic decision-making that occurs in the clinical backstage;

Theme 4: Characteristics Change How Teams (and Individuals) Perform a Diagnosis (in section 4.5)

How teamwork changes with different diagnostic situations; and finally

Theme 5: Sources of Error Through Teamwork and Diagnosis (in section 4.6)

Considerations for how diagnostic errors may occur among teams through errors of both individual and team decision-making.

Suggestions for future studies highlights gaps that remain. Lastly, implications for current practice with considerations towards changing provider team training and education are suggested. Finally, limitations of this study are discussed, followed by conclusions.

4.2 Theme 1: Teamwork in Diagnosis is Regular, Important, and Flexibly Defined

4.2.1 Why Teamwork Occurs Regularly

Teamwork is perceived to regularly occur in diagnosis because of the number of roles involved, the nature of academic medicine, and to benefit patient outcomes. Participants emphasized that diagnosis is not limited to an individual making decisions alone. Participants viewed team decision making as a support system in recognizing others for their contributions, and in being aware of not knowing everything. In addition, teamwork generates disagreements that are usually resolved but not documented, and may be critical to arriving at a diagnosis. In an intensive and high severity specialty such as the ICU, teamwork is important in the ICU for outcomes (Rothschild et al. 2006). The I.O.M report concluded that diagnosis is a team-based activity consisting of contributions from various roles, including specific roles such as radiology and nursing, that typically do not receive sufficient recognition for their contributions towards diagnosis (Balogh, Miller, and Ball 2016).

Compared to statements that diagnosis is a team-based activity, counter points also were obtained. Participants described situations where diagnosticians should first attempt to perform any diagnostic tasks themselves before obtaining assistance. Participants that stated such counter points still emphasized the occurrence of assistance seeking, such as from the attending physician and that teamwork ultimately may be necessary in some situations. Sometimes, teamwork was described to occur with minimal contributions from multiple providers to reach a diagnosis. These statements suggest that some diagnoses are seen as independent tasks that connect individuals through simple information exchanges, whereas teamwork occurs to deal with the imperfection surrounding the patient's ability to provide a history, the fallible nature of medical decision-making by individuals working alone, and the shared gain from clinical expertise. Perceptions of providers in needing to make independent diagnoses partially can be explained because of the culture surrounding medical practice that doctors should be infallible and not rely on others (Patel et al. 2011). In summary, our findings that participants

perceive diagnosis as a team-based activity is supported by literature (Balogh, Miller, and Ball 2016), and places a greater emphasis on studying diagnosis as a team activity.

4.2.2 Why Teamwork Is Important

The perception that *teamwork is important for patient outcomes can be explained by the perceived benefits of teamwork*: benefits for the patient through diagnosis and treatment.

Therefore, effective teamwork occurs for the patient's best interests. Diagnostic teamwork has the potential to improve outcomes (Graber et al. 2012, Balogh, Miller, and Ball 2016), making providers consider good teamwork between and across roles as essential to provide good patient care. Additionally, literature specifically supports the perception that medical teamwork increases idea generation (Kerr and Tindale 2004) and leads to better outcomes in healthcare (Ellingson 2003).

This is the first study to report provider perceptions about their awareness and importance of diagnostic teamwork. It is not surprising that providers have the patient at the center of practice. Through improved understanding of diagnostic team functioning and structure, the training and education of diagnostic teams may improve with outcomes of team effectiveness.

4.2.3 Why Teamwork Lines Are Blurred

The lines between teamwork for treatment and diagnosis were blurred in participants' description of their perceptions. The iterative nature of diagnosis and treatment in MICU practice explains why it may have been difficult for participants to clearly separate the two in their interview responses. MICU provider objectives include sufficient stabilization of the patient (Patel, Kaufman, and Magder 1996) for discharge. An early differential diagnosis is reached which determines early treatment, which then permits time for the diagnosticians to deliberate on alternative diagnoses and explore different procedural options (Balogh, Miller, and Ball 2016). Further, providers have overlapping roles that factor into treatment and diagnosis, such

as the nurse who regularly has important roles in treatment but ambiguous roles in diagnosis. In addition, how diagnosticians are educated and trained likely factors into blurred identification between clinical tasks.

The blurring of boundaries between treatment and diagnosis has an influence on the transferability of lessons learned from teams outside of clinical diagnosis to diagnostic teams. In particular, research has questioned the utility of transferring teamwork error methods from treatment teamwork to diagnostic teamwork (Balogh, Miller, and Ball 2016). While some research has suggested that lessons learned from aviation teams and healthcare teams in treatment may generally be transferred to diagnostic teams (Thomas, Sexton, and Helmreich 2004) for structure and functioning, other literature suggests uncertainty in transferability due to the fluidity of diagnostic provider membership. Our findings on the fluidity of providers involved in diagnostic teamwork, as well as non-clear delineations of contributions and team identity, demonstrates the need for further study in diagnostic teamwork (Balogh, Miller, and Ball 2016).

4.3 Theme 2: Team Identity Corresponds with Diagnostic Contributions

4.3.1 Understanding diagnostic contributions

Seeking to understand how diagnostic team structure relates to team functioning, this study found that team identity is associated with regular and formal diagnostic contributions in decision-making. The four roles in this study including the attending physician, fellow, resident, and nurse practitioner. Each role identified their own role as being a part of the diagnostic team, in addition to the three other interviewed roles. However, perceptions were not unanimous in agreement for the team identify of roles other than the four interviewed roles.

Behavioral science literature shows that team identity correlates with increased team performance and improved outcomes in decision-making (Desivilya, Somech, and Lidgoster 2010). The open and non-judgmental environment as described by study participants positively facilitates open discussion and contributions without the potential for losing face (Tschan et al. 2009). As corroborated by literature, by feeling more “a part of the team”, MICU team members

are more likely to participate and speak up (Waller and Uitdewilligen 2008) regarding diagnostic perspectives. The open environment for team participation described by participants suggests greater team cohesion. Therefore, the open and encouraging environment should lead to better patient outcomes through improved diagnostic performance.

This study describes team identity and decision-making contributions solely based on participants' perceptions. However, it must be noted that perceived team identity and actual contributions in practice towards diagnosis might differ. For instance, some roles may receive less team identification but still significantly contribute to diagnostic decision-making. In such situations, there exists an opportunity to improve collaboration through recognition, as team identity leads to more beneficial team behaviors (Brickson 2000) in diagnosis and thus better diagnostic outcomes. Therefore, further discussion on who forms a part of the diagnostic team, who contributes to diagnostic decision-making and how contributions occur is needed. Specifically, how the team identities obtained in this study compare with other ICU providers such as nurses, imaging and laboratory providers such as radiologists and pathologists, and the patients and patient families is of interest.

4.3.2 Nurses

Literature suggests nurses are often not recognized as diagnostic collaborators, but play critical roles in communication and identification of diagnoses (Balogh, Miller, and Ball 2016). Results suggest participants agree with literature that nurses traditionally do not facilitate decision-making relevant to diagnosis. However, they do infrequently but significantly contribute to diagnostic decision-making, and play regular and critically important roles in treatment. Nurses' involvement in patient admission (nurses are involved only after patients are admitted by the fellow and resident or nurse practitioner) within the MICU can explain the limited recognition they receive for diagnostic contributions. However, there are times when nursing roles are perceived to receive higher team identity due to provider unfamiliarity with the MICU or

being fresh from job training. Such situations warrant further study and can help expand the less-identified role of nurses in diagnostic decision-making.

Questions arise regarding the ideal team identity and contributions of nurses for diagnosis. Considerations include defining the benefits obtained by increasing the involvement of nursing and understanding why their diagnostic contributions are perceived as less frequent or less influential.

4.3.3 Patients and Patient Family

One participant identified the patient as a part of the diagnostic team, while several participants described the patient family as a part of the diagnostic team. Patients and their families were described primarily in acting as sources of information due to limited ability to participate. Instances for which patients are unable to be a part of the diagnostic team or contribute in diagnostic discussions include when patients are intubated or unconscious.

Literature suggests patients and patient families should play crucial roles and be partners in diagnostic engagement (Balogh, Miller, and Ball 2016). In a setting such as the MICU, the role of the patient may be diminished due to severe illness or their inability to participate in information sharing and decision-making, making the role of patient families more expanded. However, questions may arise regarding the effect of having little to no team identity towards shared decision-making between providers and patients. Specifically, if no team identity is perceived towards patients, whether or not diagnostic outcomes are effected. Perhaps conscious patients are seen as a part of the diagnostic team. Regardless, in an area where the patient is routinely unable to participate in the collection of the HPI, quality care must still be offered. In addition, this study did not collect patient perceptions regarding their involvement of the diagnostic process nor in team identity. Therefore, further study is needed regarding the benefits of having the patient perceived as a part of the diagnostic team, how to improve team identity of patients, and how involved patients feel regarding their diagnostic process.

4.3.4 Other: Provider Family

Further, contributions of those who participate in diagnostic decision-making but do not receive team identity, such as the provider's family member, should be explored. The instance of a provider's family or close friends not associated with a patient's care contributing to diagnostic decision-making has not been studied in literature.

Friends and family of providers who are sought after for diagnostic advice may equate to consulting services, there is an opportunity for discussion about their role in making a diagnosis. For example, understanding if any documentation currently occurs for such assistance and the positive or negative effects of informal advice such as improved idea generation or increased likelihood for cognitive error would help evaluate the utility of such strategies. Friends or family providing decision-making support may become a regular part of practice and warrants further study and discussions regarding the effects on patient outcomes.

4.4 Theme 3: Diagnostic Contributions in the Clinic Backstage

Participants from each role described teamwork as consisting of several types of interactions: discussions with other primary diagnosticians assigned to the patient's care, working with nurses and other less identified providers assigned to the patient, requesting consulting services from other departments, and discussions with providers not assigned to the patient. Therefore, a significant amount of diagnostic decision-making and teamwork occurs in the backstage for those not seen as a part of the diagnostic team. Informal advice is regularly given and sought after for complex patient cases consisting of highly severe patients or where feelings of diagnostic uncertainty exist. Backstage diagnostic teamwork occurs informally and includes participation of providers that lack diagnostic team identity, and the influence of such teamwork upon diagnostic outcomes is not known. Literature supports the existence and influence of the clinical backstage (Ellingson 2003). Role of the backstage has been studied with applications towards expertise and learning (Patel, Kaufman, and Magder 1996). In

summary, the influence of diagnostic backstage on team decision-making and diagnostic outcomes including errors has not been studied.

Quite interestingly, while research conclusions regarding clinical backstage are novel, these findings do not surprise providers in practice given how these backstage practices become a routine part of what they do. The use of regular diagnostic contributions from providers not assigned to a patient's care may not sound novel to providers and diagnosticians, especially in an academic setting. Compared to non-academic hospitals, teaching hospitals present opportunities for increased collaboration through bureaucratic and hierarchical relationships that involve supervision and education (Cicourel 1987). Within academic hospitals, there is an opportunity to understand the diagnostic backstage with motivations to improve quality practice in two ways: one, to potentially identify unrecognized sources of error; and two, to understand how to improve error reduction method effectiveness. The clinic backstage presents a novel area to explore in order to better understand the diagnostic process and how it fails with diagnostic errors. The diagnostic backstage supports training and is a regular part of practice, but it is unknown what role the backstage plays in diagnostic error occurrence and prevention. Future studies should study the effects of the situated diagnostic team, as opposed to controlled settings, in order to capture these effects.

4.5 Theme 4: Characteristics Change How Teams (and Individuals) Perform a Diagnosis

Diagnostic teams include members with various levels of expertise in focused specialties. The increase in teamwork under varying diagnostic circumstances reflects strategies to manage evolving situations of diagnostic uncertainty, high severity, or diagnostic difficulty.

Diagnostic uncertainty has been reported to not correlate with diagnostic accuracy (Cameron, McGoogan, and Watson 1980, Podbregar et al. 2001), however the effect of diagnostic uncertainty on team decision-making has not been studied. One possibility is that more errors are caused by overconfidence gained through agreement from team-members

when perspectives are sought after to deal with diagnostic uncertainty. The study model (Figure1) demonstrates how this example can be studied in two ways. First, field studies may observe for instances of explicit error through observations and follow-up. By specifically searching for one situation of error risk, the daunting task of witnessing diagnostic error may arguably be more manageable. Second, future studies may perform simulated studies that simulate situations diagnostic error risk among teams, instead of a single individuals (Schmidt et al. 2014) or a duo of peers (Hautz et al. 2015), in order to determine if errors occur are at high risk to occur. Altogether, varying team and patient presentations could benefit from field studies and simulated studies to control and examine the risk for diagnostic error.

Similar to section 4.4.1 discussing the regularity of the diagnostic backstage, the consideration of different patient presentations leading to different role involvements and procedures may not be surprising to practicing providers. However, such considerations are lacking in research studying diagnostic decision-making and diagnostic error and suggest new areas of applications and methods.

4.6 Theme 5: Sources of Error Through Teamwork and Diagnosis

Although not included in interview questions within this study, participants described five causes of diagnostic error: failure to share crucial information, failure to correctly emphasize crucial information, failure to listen to information, overconfidence, and failure in collecting a patient's history. The findings from this study on the causes of diagnostic error are well supported by the literature, especially on overconfidence, (Berner and Graber 2008), failure to sufficiently collect the patient history or physical (Graber, Franklin, and Gordon 2005), and communication issues (Ogdie et al. 2012, Christensen et al. 2000). What remains unknown is how causative factors of diagnostic error occur in tandem in regards to diagnostic error occurrence and patient harm. Two examples are considered: overconfidence and failure to collect a patient's history.

The first example examines how the risk for overconfidence changes when another provider's input is sought and obtained for a diagnosis. Overconfidence in individual diagnosticians has been studied by directly questioning physicians about the confidence of their diagnoses and has shown that overconfident diagnosticians underappreciate the likelihood that their diagnosis is incorrect (Berner & Graber, 2008). However, the effects of overconfidence on teamwork in diagnosis has not been studied. How a team member's agreement influences the risk for the cognitive error of anchoring is not known: agreement may be provided in a form of social loafing without critical consideration (Dayton and Henriksen 2007). Alternatively, the risk for error may decrease due to the benefits of utilizing multiple perspectives that catch mistakes made by other providers instead of incorrectly instilling confidence towards early differential diagnoses.

As a second example, failure in collecting a patient's history has been studied among individuals as a causative factor of error. Among individual cognitive contributions to diagnostic error, a significant amount of errors are thought to occur from an diagnostician's "ineffective, incomplete or faulty" work-up, history, and physical examination or HPI (Graber, Franklin, and Gordon 2005). However this is not to suggest that collecting more history is better: it is not necessary to collect an entire history which would also represent a waste of time and resources, and the correct diagnosis does not correlate with an entirely complete history (Kuhn 2002). Therefore, the benefits of having more than one team member collect a patient's history and physical, such as when the resident and fellow perform the HPI, simply may be concluded as reducing the risk for error.

These two examples of error occurrence among teams suggest areas for future studies to explore by studying errors in controlled, simulated settings of induced error through distracting factors among single participants (Mamede et al. 2014), and among teams.

4.7 Areas of Future Study

This is the first study to report that providers perceive diagnosis as being performed primarily by teams or combinations of individuals working together. These findings underline the importance of studying diagnosis and diagnostic error as a team-based activity. These findings also raise questions whether studies of single diagnosticians or small groups in controlled settings sufficiently capture the teamwork that occurs to make a regular diagnosis in an academic setting. Further, as the research community begins to explore and test the effectiveness of cognitive countermeasures towards diagnostic errors, such countermeasures should be explored in use among teams. Teams present novel sources of encouraging second opinions towards diagnostic outcomes. Thus, error reduction methods should target and emphasize teams.

4.7.1 Unit of Analysis

Studies of diagnostic error have so far primarily focused on the individual. This study suggests that future research should be performed with the team as the unit of analysis as opposed to the individual diagnosticians. For instance, simulated studies examine the various contributions of each individual towards diagnostic error. Studies also may explore how errors occur or are caught among multiple decision-making team members. The potential exists for studying the diagnostic team as the unit of analysis and new models may be derived and explored to understand the role of teamwork in diagnosis.

4.7.2 Methods

In order to study the diagnostic team, the fields of cognitive engineering and human factors present approaches that expand upon other methods or are novel to diagnosis and diagnostic error research.

Current models or theories of diagnostic decision-making can extend and adapt models to shared decision-making. Based on the understanding of how an individual performs a clinical

diagnosis, the dual decision-making model (Croskerry 2009a) may be explored for diagnostic teams. Such models may be expanded upon or adapted to encompass multiple decision-makers.

Some researchers have used or are beginning to apply such methods including cognitive work analysis (Nystrom et al. 2016), and situational awareness (Singh, Petersen, and Thomas 2006), yet the potential exists for applying team methods such as team situational awareness or team cognitive work analysis as explored in other healthcare teams (Ashoori and Burns 2013). These methods may be able to capture elements such as teamwork that occurs in the backstage. Such elements may occur outside of studies that are too controlled. Further, the model created in this study may help facilitate discussion and assist future studies by demonstrating how teams may be modeled in action, but the real issues in gaps of understanding will be best addressed through team situational awareness, team mental models, and team cognition such as distribution cognition.

4.7.3 Target Areas of Diagnostic Team Error

Participants mentioned sources of error due to teamwork and individual reasoning in the diagnostic process. The errors as described by participants in this study are not new to literature on overconfidence, (Berner and Graber 2008), failure to sufficiently collect the patient history or physical (Graber, Franklin, and Gordon 2005), and communication issues (Ogdie et al. 2012, Christensen et al. 2000). However, the combined effects of each error being propagated or reduced among diagnostic teams has not been studied.

Disagreements in diagnosis occur in an open environment where any provider may contribute. Each of the four interviewed roles described conferring those with more or less experience, such as when an attending physician asks a medical student for advice. In admitting that they seek others' input, participants' acknowledged that it is infeasible to know everything. These results suggest that disagreement represents a potential step to catch and

prevent errors from occurring as a normal part of care. Further, disagreements represent a potential source of error occurrence due to a lack of documentation.

4.7.4 Applications: Take-Home Points for Providers

Aside from target areas of future study, this thesis suggests the need for discussion among practitioners regarding diagnostic team structure and functioning. Discussions may be held regarding who contributes and should contribute to diagnostic decision-making, as well as who is and should be identified as a part of the diagnostic team. Through increased and more accurate representations of team structure and functioning, as well as open discussion and contribution of ideas, the diagnostic process may be improved for task efficiency, accuracy with patient outcomes, and team member satisfaction.

Second, ramifications of such discussions may influence and improve education and training for teamwork. The model created in this study may help facilitate discussion among providers by demonstrating that teamwork is a dynamic process that changes distinctly with various patient presentations and levels of uncertainty the providers experience throughout different levels of training. Results may further support the need and benefits of earlier training and interventions regarding team collaboration.

4.8 Limitations

The interviews performed in this study were not intended to be sufficient basis for fully understanding diagnostic decision making and teamwork that occurs in all teaching hospitals, MICUs, or ICUs. Yet efforts were made to avoid the effects of such limitations so that the lessons learned from this study, in addition to the methods and approaches, may be an motivation for other settings to perform future studies on team diagnostic decision-making.

This study used convenience sampling which has several advantages including cost, time, and effort; but it may be considered the least rigorous technique (Marshall 1996). In spite of this drawback, convenience sampling still provides rich data and this approach provided the

best fit to address the study motivations of understanding provider perceptions. While ideally every MICU provider would have been interviewed, the results from this study population still provided a significant amount of data and qualitative data saturation was obtained.

It was also possible for the researcher to inaccurately interpret what participants stated. This is an inherent part of qualitative interviews but the semi-structured interview was again determined to be the best method to address the research questions. This limitation was addressed through several approaches: deliberate consideration of interview questions to leave little room for interpretation of responses, the researcher asked follow-up questions if things were unclear, and the use of confirmation questions and statements. Further, the researcher sought to understand what providers were describing without any preconceived notions and attempted to see things from the provider's perspective. During data preparation and analysis, revising the codes based on consensus between the researcher and the research mentor further reduced chances of inaccurate interpretations.

It also was possible for participants to provide, intentionally or unintentionally, inaccurate responses in the form of misinformation. This was reduced by anonymizing participation and responses, as well as describing the objectives of this study as to not judge practices but rather improve understanding.

Finally, the generalizability of this study in application to non-teaching hospitals may be questioned. While the specific findings of this study surrounding the supervision and education roles of teamwork in diagnostic decision-making may not be directly transferable to hospitals which this relationship, the questions surrounding team structure and functioning may still be applied. For example, non-teaching hospitals may have smaller sizes of teams, however performing a clinical diagnosis is still recognized as a team-based activity (Balogh, Miller, and Ball 2016) and diagnostic errors occur in every specialty (Berner and Graber 2008). Therefore, issues of identity and contributions may be explored in any situation for which multiple providers work together to reach a diagnosis. Whether minimal to significant decision-making occurs

between roles, teamwork is still involved in each type of setting and presents an opportunity to improve the diagnostic process and improve outcomes.

In summary, future studies performed within a situated setting are necessary to determine how providers work together as a team to complete a diagnosis. This thesis study posits that provider perceptions are a worthy area to begin exploration on the most common areas at risk for diagnostic error.

4.9 Conclusions

In conclusion, the purpose of the study was to obtain MICU provider perceptions on the role of teamwork in diagnosis. Although we know that that diagnosis is a team activity among specialties including intensive care, limited knowledge existed regarding the perceptions of diagnostician providers about the role of teamwork in diagnosis. Study findings indicated that clinical diagnoses involve teamwork in the form of shared interdependence and team interdependence. Diagnostic team identity, structure, and functioning under patient and provider characteristics were examined and thematically modelled to present new areas and approaches to studying diagnostic decision making. Study implications suggest further situated studies on team diagnostic decision-making and team diagnostic error for an in-depth understanding.

REFERENCES

2014. *Patient Safety in Surgery*. Edited by Philip F; Mauffrey Stahel, Cyril: Springer-Verlag London.
- ATLAS.ti: Qualitative Data Analysis Inc. ATLAS.ti Scientific Software 500 Development GmbH, Berlin, Germany.
2017. "Society to Improve Diagnosis in Medicine." accessed April 17th, 2017. <http://www.improvediagnosis.org/>.
- Afzalur Rahim, M, Nace R Magner, and Debra L Shapiro. 2000. "Do justice perceptions influence styles of handling conflict with supervisors?: What justice perceptions, precisely?" *International Journal of Conflict Management* 11 (1):9-31.
- Apker, Julie, Kathleen M Propp, and Wendy S Zabava Ford. 2005. "Negotiating status and identity tensions in healthcare team interactions: An exploration of nurse role dialectics." *Journal of Applied Communication Research* 33 (2):93-115.
- Arazy, Ofer, Lisa Yeo, and Oded Nov. 2013. "Stay on the Wikipedia task: When task-related disagreements slip into personal and procedural conflicts." *Journal of the American Society for Information Science and Technology* 64 (8):1634-1648.
- Artman, Henrik, and Yvonne Wærn. 1999. "Distributed cognition in an emergency co-ordination center." *Cognition, Technology & Work* 1 (4):237-246.
- Ashforth, Blake E, and Fred Mael. 1989. "Social identity theory and the organization." *Academy of management review* 14 (1):20-39.
- Ashmore, Richard D, Kay Deaux, and Tracy McLaughlin-Volpe. 2004. "An organizing framework for collective identity: articulation and significance of multidimensionality." *Psychological bulletin* 130 (1):80.
- Ashoori, Maryam, and Catherine Burns. 2013. "Team cognitive work analysis: Structure and control tasks." *Journal of Cognitive Engineering and Decision Making* 7 (2):123-140.
- Atwal, Anita, and Kay Caldwell. 2005. "Do all health and social care professionals interact equally: a study of interactions in multidisciplinary teams in the United Kingdom." *Scandinavian Journal of Caring Sciences* 19 (3):268-273.
- Ayres, Lioness, Karen Kavanaugh, and Kathleen A Knafl. 2003. "Within-case and across-case approaches to qualitative data analysis." *Qualitative health research* 13 (6):871-883.
- Balogh, Erin P, Bryan T Miller, and John R Ball. 2016. *Improving Diagnosis in Health Care*: National Academies Press.
- Beckmann, Ursula, Christian Bohringer, Ruth Carless, Donna M Gillies, William B Runciman, Albert W Wu, and Peter Pronovost. 2003. "Evaluation of two methods for quality improvement in intensive care: facilitated incident monitoring and retrospective medical chart review." *Critical care medicine* 31 (4):1006-1011.
- Berner, E. S., and M. L. Graber. 2008. "Overconfidence as a cause of diagnostic error in medicine." *Am J Med* 121 (5 Suppl):S2-23. doi: 10.1016/j.amjmed.2008.01.001.
- Bracco, David, Jean-Baptiste Favre, Bruno Bissonnette, Jean-Blaise Wasserfallen, Jean-Pierre Revelly, Patrick Ravussin, and René Chioléro. 2001. "Human errors in a multidisciplinary intensive care unit: a 1-year prospective study." *Intensive care medicine* 27 (1):137-145.
- Brickson, Shelley. 2000. "The impact of identity orientation on individual and organizational outcomes in demographically diverse settings." *Academy of management Review* 25 (1):82-101.
- Caldwell, Kay, and Anita Atwal. 2003. "The problems of interprofessional healthcare practice in hospitals." *BRITISH JOURNAL OF NURSING-LONDON-MARK ALLEN PUBLISHING LIMITED-* 12:1212-1219.
- Cameron, HM, Euphemia McGoogan, and Helen Watson. 1980. "Necropsy: a yardstick for clinical diagnoses." *Br Med J* 281 (6246):985-988.

- Campion, Michael A, Ellen M Papper, and Gina J Medsker. 1996. "Relations between work team characteristics and effectiveness: A replication and extension." *Personnel psychology* 49 (2):429-452.
- Cannon-Bowers, Janis A, and Eduardo Salas. 1998. "Individual and team decision making under stress: Theoretical underpinnings."
- Chen, Ming-Huei. 2006. "Understanding the benefits and detriments of conflict on team creativity process." *Creativity and innovation management* 15 (1):105-116.
- Christensen, Caryn, James R Larson, Ann Abbott, Anthony Ardolino, Timothy Franz, and Carol Pfeiffer. 2000. "Decision making of clinical teams: Communication patterns and diagnostic error." *Medical Decision Making* 20 (1):45-50.
- Cicourel, Aaron V. 1987. "Cognitive and organizational aspects of medical diagnostic reasoning." *Discourse Processes* 10 (4):347-367.
- Cohen, Susan G, and Diane E Bailey. 1997. "What makes teams work: Group effectiveness research from the shop floor to the executive suite." *Journal of management* 23 (3):241.
- Combes, Alain, Mourad Mokhtari, Anne Couvelard, Jean-Louis Trouillet, Jérôme Baudot, Dominique Hénin, Claude Gibert, and Jean Chastre. 2004. "Clinical and autopsy diagnoses in the intensive care unit: a prospective study." *Archives of Internal Medicine* 164 (4):389-392.
- Cooley, Elizabeth. 1994. "Training an interdisciplinary team in communication and decision-making skills." *Small group research* 25 (1):5-25.
- Corbin, Juliet, and Anselm Strauss. 2008. "Basics of qualitative research: Techniques and procedures for developing grounded theory."
- Corker, K, D Kieras, J Payne, and P Reuter-Lorenz. 1992. "Cognitive effort and cognitive complexity." *Human Performance in the Complex Workplace: Implications for Basic Research in Cognitive Science. Buffalo: State University of New York at Buffalo:17-23.*
- Croskerry, Pat. 2009a. "Clinical cognition and diagnostic error: applications of a dual process model of reasoning." *Advances in health sciences education* 14 (1):27-35.
- Croskerry, Pat. 2009b. "A universal model of diagnostic reasoning." *Academic Medicine* 84 (8):1022-1028.
- Cummings, Thomas G. 1981. "Designing effective work groups." *Handbook of organizational design* 2:250-271.
- Dawson, Neal V. 1993. "Physician judgment in clinical settings: methodological influences and cognitive performance." *Clinical Chemistry* 39 (7):1468-1478.
- Dayton, Elizabeth, and Kerm Henriksen. 2007. "Communication failure: basic components, contributing factors, and the call for structure." *The Joint Commission Journal on Quality and Patient Safety* 33 (1):34-47.
- De Dreu, Carsten KW, and Evert Van de Vliert. 1997. *Using conflict in organizations*: Sage.
- De Dreu, Carsten KW, and Laurie R Weingart. 2003. Task versus relationship conflict, team performance, and team member satisfaction: a meta-analysis. American Psychological Association.
- DeChurch, Leslie A, and Jessica R Mesmer-Magnus. 2010. The cognitive underpinnings of effective teamwork: a meta-analysis. American Psychological Association.
- Desivilya, Helena Syna, Anit Somech, and Helena Lidgoster. 2010. "Innovation and conflict management in work teams: The effects of team identification and task and relationship conflict." *Negotiation and Conflict Management Research* 3 (1):28-48.
- Dey, I. 1999. Grounding grounded theory. Guidelines for qualitative research. London: Academic Press.
- Dietrich, Allen J, Thomas E Oxman, John W Williams, Herbert C Schulberg, Martha L Bruce, Pamela W Lee, Sheila Barry, Patrick J Raue, Jean J Lefever, and Moonseong Heo. 2004. "Re-engineering systems for the treatment of depression in primary care: cluster randomised controlled trial." *Bmj* 329 (7466):602.

- Dionne, Shelley D, Francis J Yammarino, Leanne E Atwater, and William D Spangler. 2004. "Transformational leadership and team performance." *Journal of organizational change management* 17 (2):177-193.
- Donchin, Yoel, Daniel Gopher, Miriam Olin, Yehuda Badihi, Michal RNB Biesky, Charles L Sprung, Ruven Pizov, and Shamay Cotev. 1995. "A look into the nature and causes of human errors in the intensive care unit." *Critical care medicine* 23 (2):294-300.
- Dustin, David S, and Henry P Davis. 1970. "Evaluative bias in group and individual competition." *The Journal of social psychology* 80 (1):103-108.
- Earley, Christopher P, and Elaine Mosakowski. 2000. "Creating hybrid team cultures: An empirical test of transnational team functioning." *Academy of Management Journal* 43 (1):26-49.
- Eckel, Catherine C, and Philip J Grossman. 2005. "Managing diversity by creating team identity." *Journal of Economic Behavior & Organization* 58 (3):371-392.
- Ellemers, Naomi, Ed Sleebos, Daan Stam, and Dick Gilder. 2013. "Feeling included and valued: How perceived respect affects positive team identity and willingness to invest in the team." *British Journal of Management* 24 (1):21-37.
- Ellingson, Laura L. 2003. "Interdisciplinary health care teamwork in the clinic backstage." *Journal of Applied Communication Research* 31 (2):93-117.
- Eva, Kevin W, and Geoffrey R Norman. 2005. "Heuristics and biases– a biased perspective on clinical reasoning." *Medical education* 39 (9):870-872.
- Fernandez-Segoviano, Pilar, Aurora Lázaro, Andres Esteban, Jose Manuel Rubio, and Jose R Iruretagoyena. 1988. "Autopsy as quality assurance in the intensive care unit." *Critical care medicine* 16 (7):683-685.
- Gladstein, Deborah L. 1984. "Groups in context: A model of task group effectiveness." *Administrative science quarterly*:499-517.
- Glaser, Barney G, and Anselm L Strauss. 2009. *The discovery of grounded theory: Strategies for qualitative research*: Transaction publishers.
- Goldman, Lee, Robert Sayson, Stanley Robbins, Lawrence H Cohn, Michael Bettmann, and Monica Weisberg. 1983. "The value of the autopsy in three medical eras." *New England Journal of Medicine* 308 (17):1000-1005.
- Goltz, Sonia M, Amy B Hietapelto, Roger W Reinsch, and Sharon K Tyrell. 2008. "Teaching teamwork and problem solving concurrently." *Journal of Management Education* 32 (5):541-562.
- Goodman, Paul S. 1979. *Assessing organizational change: The Rushton quality of work experiment*: John Wiley & Sons.
- Graber, M. L. 2013. "The incidence of diagnostic error in medicine." *BMJ Qual Saf* 22 Suppl 2:ii21-ii27. doi: 10.1136/bmjqs-2012-001615.
- Graber, M. L., S. Kissam, V. L. Payne, A. N. Meyer, A. Sorensen, N. Lenfestey, E. Tant, K. Henriksen, K. Labresh, and H. Singh. 2012. "Cognitive interventions to reduce diagnostic error: a narrative review." *BMJ Qual Saf* 21 (7):535-57. doi: 10.1136/bmjqs-2011-000149.
- Graber, Mark. 2005. "Diagnostic errors in medicine: a case of neglect." *The Joint Commission Journal on Quality and Patient Safety* 31 (2):106-113.
- Graber, Mark L, Nancy Franklin, and Ruthanna Gordon. 2005. "Diagnostic error in internal medicine." *Archives of internal medicine* 165 (13):1493-1499.
- Grant, Richard W, Jeffrey M Ashburner, Clemens S Hong, Yuchiao Chang, Michael J Barry, and Steve J Atlas. 2011. "Defining Patient Complexity From the Primary Care Physician's PerspectiveA Cohort Study." *Annals of Internal Medicine* 155 (12):797-804.
- Hackman, J Richard, and Greg R Oldham. 1980. "Work redesign."
- Hackman, JR. 1987. The design of work teams. Inj. w. lorsch (ed.), *Handbook of organizational behavior* (pp. 315-342). Englewood cliffs, nj: prentice-hall.

- Hautz, W. E., J. E. Kämmer, S. K. Schaubert, C. D. Spies, and W. Gaissmaier. 2015. "Diagnostic performance by medical students working individually or in teams." *JAMA* 313 (3):303-304. doi: 10.1001/jama.2014.15770.
- Houghton, Susan M, Mark Simon, Karl Aquino, and Caren B Goldberg. 2000. "No safety in numbers: Persistence of biases and their effects on team risk perception and team decision making." *Group & Organization Management* 25 (4):325-353.
- Hudson, Bob. 2002. "Interprofessionality in health and social care: the Achilles' heel of partnership?" *Journal of interprofessional care* 16 (1):7-17.
- Islam, Roosan, C Weir, and G Del Fiol. 2016. "Clinical complexity in medicine: a measurement model of task and patient complexity." *Methods of information in medicine* 55 (1):14-22.
- Jehn, Karen A, and Elizabeth A Mannix. 2001. "The dynamic nature of conflict: A longitudinal study of intragroup conflict and group performance." *Academy of management journal* 44 (2):238-251.
- Kalra, Jawahar. 2004. "Medical errors: impact on clinical laboratories and other critical areas." *Clinical biochemistry* 37 (12):1052-1062.
- Kanter, David E, Wendy Turenne, and Anthony D Slonim. 2004. "Hospital-reported medical errors in premature neonates." *Pediatric Critical Care Medicine* 5 (2):119-123.
- Kassirer, Jerome P, and Richard I Kopelman. 1989. "Cognitive errors in diagnosis: instantiation, classification, and consequences." *The American journal of medicine* 86 (4):433-441.
- Keegan, Mark T, Ognjen Gajic, and Bekele Afessa. 2011. "Severity of illness scoring systems in the intensive care unit." *Critical care medicine* 39 (1):163-169.
- Kempainen, Robert R, Mary B Migeon, and Fredric M Wolf. 2003. "Understanding our mistakes: a primer on errors in clinical reasoning." *Medical teacher* 25 (2):177-181.
- Kerr, Norbert L, and R Scott Tindale. 2004. "Group performance and decision making." *Annu. Rev. Psychol.* 55:623-655.
- Keyton, Joann. 1999. "Relational communication in groups." *The handbook of group communication theory and research*:192-222.
- Klein, Gary. 1999. *Sources of power: How people make decisions*: MIT press.
- Klein, Gary. 2008. "Naturalistic decision making." *Human Factors: The Journal of the Human Factors and Ergonomics Society* 50 (3):456-460.
- Kondro, Wayne. 2010. "Medical errors increasing because of complexity of care and breakdown in doctor-patient relationship, physician consultant says." *CMAJ*, accessed April 17th, 2017.
- Kreindler, Sara A, Damien A Dowd, NOAH Dana Star, and Tania Gottschalk. 2012. "Silos and social identity: the social identity approach as a framework for understanding and overcoming divisions in health care." *The Milbank Quarterly* 90 (2):347-374.
- Kuhn, Gloria J. 2002. "Diagnostic errors." *Academic Emergency Medicine* 9 (7):740-750.
- Leape, Lucian, Troyen A Brennan, Nan Laird, Ann G Lawthers, A Russell Localio, Benjamin A Barnes, Liesi Hebert, Joseph P Newhouse, Paul C Weiler, and Howard Hiatt. 1991. "The nature of adverse events in hospitalized patients: results of the Harvard Medical Practice Study II." *New England journal of medicine* 324 (6):377-384.
- Leape, Lucian., Berwick, Donald M., Bates, David W. 2002. "In Reply, Counting deaths due to medical errors." *JAMA* 288 (19):2405-2405.
- Lingard, Lorelei, Sherry Espin, Cathy Evans, and Laura Hawryluck. 2004. "The rules of the game: interprofessional collaboration on the intensive care unit team." *Critical care* 8 (6):R403.
- Lisak, Alon, and Miriam Erez. 2009. "Leaders and followers in multi-cultural teams: their effects on team communication, team identity and team effectiveness." Proceedings of the 2009 international workshop on Intercultural collaboration.

- Mamede, Sílvia, Henk G Schmidt, and Remy Rikers. 2007. "Diagnostic errors and reflective practice in medicine." *Journal of evaluation in clinical practice* 13 (1):138-145.
- Mamede, Sílvia, Tamara Van Gog, Kees Van Den Berge, Jan LCM Van Saase, and Henk G Schmidt. 2014. "Why do doctors make mistakes? A study of the role of salient distracting clinical features." *Academic Medicine* 89 (1):114-120.
- Marshall, Martin N. 1996. "Sampling for qualitative research." *Family practice* 13 (6):522-526.
- Maxwell, Joseph. 1992. "Understanding and validity in qualitative research." *Harvard educational review* 62 (3):279-301.
- Miles, Matthew B, and A Michael Huberman. 1994. "Qualitative data analysis: A sourcebook." *Beverly Hills: Sage Publications*.
- Mitchell, Rebecca J, Vicki Parker, and Michelle Giles. 2011. "When do interprofessional teams succeed? Investigating the moderating roles of team and professional identity in interprofessional effectiveness." *Human relations* 64 (10):1321-1343.
- Mort, Thomas C, and Neil S Yeston. 1999. "The relationship of pre mortem diagnoses and post mortem findings in a surgical intensive care unit." *Critical care medicine* 27 (2):299-303.
- Newman-Toker, David E, and Martin A Makary. 2013. "Measuring Diagnostic Errors in Primary Care: The First Step on a Path Forward Comment on "Types and Origins of Diagnostic Errors in Primary Care Settings"." *JAMA internal medicine* 173 (6):425-426.
- Newman-Toker, David E, and Peter J Pronovost. 2009. "Diagnostic errors—the next frontier for patient safety." *JAMA* 301 (10):1060-1062.
- Norman, G. R., and K. W. Eva. 2010. "Diagnostic error and clinical reasoning." *Med Educ* 44 (1):94-100. doi: 10.1111/j.1365-2923.2009.03507.x.
- Nystrom, Daniel T., Linda Williams, Douglas E. Paull, Mark L. Graber, and Robin R. Hemphill. 2016. "A Theory-Integrated Model of Medical Diagnosis." *Journal of Cognitive Engineering and Decision Making* 10 (1):14-35. doi: 10.1177/1555343415618965.
- Ogdie, A. R., J. B. Reilly, W. G. Pang, S. Keddem, F. K. Barg, J. M. Von Feldt, and J. S. Myers. 2012. "Seen through their eyes: residents' reflections on the cognitive and contextual components of diagnostic errors in medicine." *Acad Med* 87 (10):1361-7. doi: 10.1097/ACM.0b013e31826742c9.
- Opie, Anne. 2000. *Thinking teams, thinking clients: knowledge-based teamwork*: Columbia University Press.
- Orasanu, Judith, and Eduardo Salas. 1993. "Team decision making in complex environments."
- Patel, Vimla L, Trevor Cohen, Tripti Murarka, Joanne Olsen, Srujana Kagita, Sahiti Myneni, Timothy Buchman, and Vafa Ghaemmaghami. 2011. "Recovery at the edge of error: debunking the myth of the infallible expert." *Journal of Biomedical Informatics* 44 (3):413-424.
- Patel, Vimla L, David R Kaufman, and Sheldon A Magder. 1996. "The acquisition of medical expertise in complex dynamic environments." *The road to excellence: The acquisition of expert performance in the arts and sciences, sports and games*:127-165.
- Podbregar, M., G. Voga, B. Krivec, R. Skale, R. Pareznik, and L. Gabrscek. 2001. "Should we confirm our clinical diagnostic certainty by autopsies?" *Intensive Care Med* 27 (11):1750-5. doi: 10.1007/s00134-001-1129-x.
- Poole, Marshall Scott, and Kevin Real. 2003. "Groups and teams in health care: Communication and effectiveness." *Handbook of health communication*:369-402.
- Porche, Demetrius J. 2016. "Diagnostic Errors Improving Diagnostic Practice." *American journal of men's health* 10 (1):5-5.
- Rajkomar, Alvin, and Gurpreet Dhaliwal. 2011. "Improving diagnostic reasoning to improve patient safety." *Permanente J* 15:68-73.
- Reese, Dona J, and Mary-Ann Sontag. 2001. "Successful interprofessional collaboration on the hospice team." *Health & Social Work* 26 (3):167-175.

- Reeves, Scott, Merrich Zwarenstein, Joanne Goldman, Hugh Barr, Della Freeth, Marilyn Hammick, and Ivan Koppel. 2008. "Interprofessional education: effects on professional practice and health care outcomes." *Cochrane Database Syst Rev* 1 (1).
- Rothschild, Jeffrey M, Ann C Hurley, Christopher P Landrigan, John W Cronin, Kristina Martell-Waldrop, Cathy Foskett, Elisabeth Burdick, Charles A Czeisler, and David W Bates. 2006. "Recovery from medical errors: the critical care nursing safety net." *The Joint Commission Journal on Quality and Patient Safety* 32 (2):63-72.
- Rothschild, Jeffrey M, Christopher P Landrigan, John W Cronin, Rainu Kaushal, Steven W Lockley, Elisabeth Burdick, Peter H Stone, Craig M Lilly, Joel T Katz, and Charles A Czeisler. 2005. "The Critical Care Safety Study: The incidence and nature of adverse events and serious medical errors in intensive care." *Critical care medicine* 33 (8):1694-1700.
- Saber Tehrani, A. S., H. Lee, S. C. Mathews, A. Shore, M. A. Makary, P. J. Pronovost, and D. E. Newman-Toker. 2013. "25-Year summary of US malpractice claims for diagnostic errors 1986-2010: an analysis from the National Practitioner Data Bank." *BMJ Qual Saf* 22 (8):672-80. doi: 10.1136/bmjqs-2012-001550.
- Sandelowski, Margarete. 2000. "Focus on research methods-whatever happened to qualitative description?" *Research in nursing and health* 23 (4):334-340.
- Sarcevic, Aleksandra, Ivan Marsic, and Randal S Burd. 2012. "Teamwork errors in trauma resuscitation." *ACM Transactions on Computer-Human Interaction (TOCHI)* 19 (2):13.
- Satin, David G. 1994. "The interdisciplinary, integrated approach to professional practice with the aged." *The clinical care of the aged person: An interdisciplinary perspective*:391-403.
- Schmidt, Henk G, Sílvia Mamede, Kees Van Den Berge, Tamara Van Gog, Jan LCM Van Saase, and Remy MJP Rikers. 2014. "Exposure to media information about a disease can cause doctors to misdiagnose similar-looking clinical cases." *Academic Medicine* 89 (2):285-291.
- Sexton, J Bryan, Eric J Thomas, and Robert L Helmreich. 2000. "Error, stress, and teamwork in medicine and aviation: cross sectional surveys." *Bmj* 320 (7237):745-749.
- Shapiro, Debra L, Stacie A Furst, Gretchen M Spreitzer, and Mary Ann Von Glinow. 2002. "Transnational teams in the electronic age: are team identity and high performance at risk?" *Journal of Organizational Behavior* 23 (4):455-467.
- Sherbino, J., K. L. Dore, T. J. Wood, M. E. Young, W. Gaissmaier, S. Kreuger, and G. R. Norman. 2012. "The relationship between response time and diagnostic accuracy." *Acad Med* 87 (6):785-91. doi: 10.1097/ACM.0b013e318253acbd.
- Shojania, K. G., E. C. Burton, K. M. McDonald, and L. Goldman. 2003. "Changes in rates of autopsy-detected diagnostic errors over time: A systematic review." *JAMA* 289 (21):2849-2856. doi: 10.1001/jama.289.21.2849.
- Singh, H., T. D. Giardina, A. N. Meyer, S. N. Forjuoh, M. D. Reis, and E. J. Thomas. 2013. "Types and origins of diagnostic errors in primary care settings." *JAMA Intern Med* 173 (6):418-25. doi: 10.1001/jamainternmed.2013.2777.
- Singh, H., L. A. Petersen, and E. J. Thomas. 2006. "Understanding diagnostic errors in medicine: a lesson from aviation." *Qual Saf Health Care* 15 (3):159-64. doi: 10.1136/qshc.2005.016444.
- Singh, Hardeep, and Safety Target. 2016. ""Diagnostic Errors: A New Chapter in Patient Safety Science, Policy, and Practice". " Agency for Healthcare Research and Quality, accessed April 18th.
- Somech, Anit, Helena Syna Desivilya, and Helena Lidogoster. 2009. "Team conflict management and team effectiveness: The effects of task interdependence and team identification." *Journal of Organizational Behavior* 30 (3):359-378.
- Stasser, Garold, and Dennis Stewart. 1992. "Discovery of hidden profiles by decision-making groups: Solving a problem versus making a judgment." *Journal of personality and social psychology* 63 (3):426.

- Sundstrom, Eric, Kenneth P De Meuse, and David Futrell. 1990. "Work teams: Applications and effectiveness." *American psychologist* 45 (2):120.
- Tai, Dessmon YH, H El-Bilbeisi, Sanjiv Tewari, Edward J Mascha, Herbert P Wiedemann, and Alejandro C Arroliga. 2001. "A study of consecutive autopsies in a medical ICU: a comparison of clinical cause of death and autopsy diagnosis." *CHEST Journal* 119 (2):530-536.
- Tajfel, Henri. 1978. *Differentiation between social groups*. London: Academic Press.
- Taplin, Stephen H, Sallie Weaver, Veronica Chollette, Lawrence B Marks, Andrew Jacobs, Gordon Schiff, Carrie T Stricker, Suanna S Bruinooge, and Eduardo Salas. 2015. "Teams and teamwork during a cancer diagnosis: Interdependency within and between teams." *Journal of Oncology Practice* 11 (3):231-238.
- Thammasitboon, S., S. Thammasitboon, and G. Singhal. 2013. "Diagnosing diagnostic error." *Curr Probl Pediatr Adolesc Health Care* 43 (9):227-31. doi: 10.1016/j.cppeds.2013.07.002.
- Thomas, Dana B, and David E Newman-Toker. 2016. "Diagnosis is a team sport—partnering with allied health professionals to reduce diagnostic errors." *Diagnosis* 3 (2):49-59.
- Thomas, EJ, JB Sexton, and RL Helmreich. 2004. "Translating teamwork behaviours from aviation to healthcare: development of behavioural markers for neonatal resuscitation." *Quality and Safety in Health Care* 13 (suppl 1):i57-i64.
- Tieman, Jennifer, Geoffrey Mitchell, Tania Shelby-James, David Currow, B Fazekas, L O'Doherty, Meg Hegarty, Lars Eriksson, R Brown, and Desley Reid-Orr. 2006. "Integration, Coordination and Multidisciplinary Approaches in Primary Care: A systematic investigation of the literature." *Canberra: Australian Primary Health Care Research Institute*.
- Tindale, R Scott. 1993. "Decision errors made by individuals and groups." *Individual and group decision making: Current issues*:109-124.
- Tomlinson, Frances. 2005. "Idealistic and pragmatic versions of the discourse of partnership." *Organization Studies* 26 (8):1169-1188.
- Tonelli, Mark R. 1998. "The philosophical limits of evidence-based medicine." *Academic Medicine* 73 (12):1234-40.
- Tschan, Franziska, Norbert K Semmer, Andrea Gurtner, Lara Bizzari, Martin Spsychiger, Marc Breuer, and Stefan U Marsch. 2009. "Explicit reasoning, confirmation bias, and illusory transactive memory: A simulation study of group medical decision making." *Small Group Research*.
- Tyler, Tom R, and Steven L Blader. 2003. "The group engagement model: Procedural justice, social identity, and cooperative behavior." *Personality and social psychology review* 7 (4):349-361.
- van den Berge, Kees, and Sílvia Mamede. 2013. "Cognitive diagnostic error in internal medicine." *European journal of internal medicine* 24 (6):525-529.
- Van Der Vegt, Gerben S, and J Stuart Bunderson. 2005. "Learning and performance in multidisciplinary teams: The importance of collective team identification." *Academy of Management journal* 48 (3):532-547.
- Vangen, Siv, and Chris Huxham. 2003. "Enacting leadership for collaborative advantage: Dilemmas of ideology and pragmatism in the activities of partnership managers." *British Journal of Management* 14 (s1).
- Vincent, Jean-Louis, and Frederico Bruzzi de Carvalho. 2010. "Severity of illness." *Seminars in respiratory and critical care medicine*.
- Voytovich, Anthony E, Robert M Rippey, and Anthony Suffredini. 1985. "Premature conclusions in diagnostic reasoning." *Academic Medicine* 60 (4):302-7.
- Wachter, Robert M. 2010. "Why diagnostic errors don't get any respect—and what can be done about them." *Health Affairs* 29 (9):1605-1610.
- Waller, Mary J, and S Uitdewilligen. 2008. "Talking to the room. Collective sensemaking during crisis situations." *Time in organisational research*. Routledge, Oxford:186-203.

- Weaver, S. J., D. E. Newman-Toker, and M. A. Rosen. 2012. "Reducing cognitive skill decay and diagnostic error: theory-based practices for continuing education in health care." *J Contin Educ Health Prof* 32 (4):269-78. doi: 10.1002/chp.21155.
- Weiss, Kevin B. 2007. "Managing complexity in chronic care: an overview of the VA state-of-the-art (SOTA) conference." *Journal of General Internal Medicine* 22 (3):374-378.
- Winters, B., J. Custer, S. M. Galvagno, Jr., E. Colantuoni, S. G. Kapoor, H. Lee, V. Goode, K. Robinson, A. Nakhasi, P. Pronovost, and D. Newman-Toker. 2012. "Diagnostic errors in the intensive care unit: a systematic review of autopsy studies." *BMJ Qual Saf* 21 (11):894-902. doi: 10.1136/bmjqs-2012-000803.
- Transana Inc. 2.50.
- Zwarenstein, M, S Reeves, H Barr, M Hammick, I Koppel, and J Atkins. 2000. "Interprofessional education: effects on professional practice and health care outcomes." *The Cochrane Library*.

APPENDIX A. INTERVIEW GUIDE

Table A.1: Finalized interview guide used in semi-structured interviews.

Collaborative Diagnostic Decision Making: Teamwork Diagnosis in the Intensive Care Unit
Session No:
Participant No:
Date:
Interview Questions:
<u>Main Question:</u>
<ul style="list-style-type: none"> • How do you make a typical diagnosis?
<u>Follow-up Questions:</u>
<ul style="list-style-type: none"> • Who do you consider part of your diagnostic team? • When do you collaborate on diagnostic decision-making? • How often do you collaborate on a diagnosis? • For how long do you work with the same people? • At what stages/tasks of diagnosis do you collaborate? • What does each role in the team do for diagnosis? • If participant agrees that diagnosis is collaborative with teamwork: <ul style="list-style-type: none"> ○ How is diagnostic decision-making different when: <ul style="list-style-type: none"> ▪ A patient case is complex? ▪ A patient is very ill? ▪ There is contradictory information/results? ▪ There is incomplete information? ▪ There is too much information? ▪ When time is urgent? ▪ When you are short-staffed? ▪ When you are uncertain? ▪ Other: can you think of any other situations when patient presentation causes differences in diagnosis?