Measuring the Process of Interprofessional Collaboration in the Care of Critically Ill Adults

by

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Dedication

This dissertation is dedicated to my two grandmothers, Grace T. Lockard and Patricia M. Boltey. They inspired me to pursue this project and to always persevere in the face of challenges.

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List of Abbreviations

IPC= Interprofessional Collaboration

MV= Mechanical Ventilation

ICU= Intensive Care Unit

CA= Collaborative Activity

RN= Registered Nurse

RT= Respiratory Therapist

MD= Doctor of Medicine

Abstract

Interprofessional collaboration (IPC), the process by which clinicians integrate their skills and knowledge to make a clinical decision or attain a patient-centered goal, is theorized to improve the quality and safety of critical care. The process of IPC is particularly important in the care of mechanically ventilated (MV) adults—a vulnerable group of critically ill patients whose care requires close collaboration between nurses, respiratory therapists, and physicians. However, a rigorous evaluation of IPC and its effects on care delivery is lacking due to measurement limitations. Specifically, prior measurement approaches have failed to operationalize IPC as a dynamic process. One possible measurement solution is applying time-motion methods, an approach from industrial and operations engineering that focuses on evaluating processes, to quantify IPC. In the current study, I tested the feasibility of using time-motion methods to measure the process of IPC in the care of MV patients. Applying the necessary steps for a time-motion study, I first developed a task list describing the IPC process and then I collected observational data in one ICU on the process of IPC in the care of MV patients using a time-motion tool. To create the task list, I analyzed a set of previously collected qualitative data consisting of observations, shadowing experiences and interviews with ICU clinicians working in two ICUs in Southeastern Michigan. Once the task list was developed, member-checking interviews were conducted with ICU clinicians to assess the validity of the developed task list. The final task list included ten "enablers to collaborative activities" and eight "collaborative activities" (18 IPC behaviors total). I defined "enablers" as the ways clinicians transition into or facilitate collaboration and "collaborative activities" as those clinician

behaviors that indicate direct engagement in collaboration. The task list was incorporated into the time-motion tool which I trained two observers, in addition to myself, to use to collect the observational data. To test the feasibility of using time-motion methods to measure the IPC process, we recruited nurses, respiratory therapists, and physicians working at a single ICU in Southeastern Michigan to participate in 3-4 hours long observations in which we collected data on the process of IPC in the care of MV patients using the time-motion tool. Following each observation session, observers also provided written feedback on their experiences collecting the data and using the tool. Descriptive statistics were analyzed to describe the frequency, and duration, at which clinicians engaged in the different behaviors on the task list. Furthermore, the observers' feedback was analyzed to identify strengths and challenges with the current data collection approach. In total, we collected 61 hours of observation with 18 different ICU clinicians (6 RNs, 6 RTs, and 6 MDs). Most of the IPC behaviors were observed at least once on 50% or more of the observation days. The results indicated wide variation in the frequency, and duration, at which the different clinician roles engaged in specific enablers and collaborative activities. After evaluating the observers' feedback, refinements to the time-motion tool and data collection approach were identified and should be tested in future work. Overall, collecting time-motion data on the process of IPC in the care of MV patients in a single ICU was found to be feasible. Clinicians engaged in IPC in diverse ways which underscores the complexity of the IPC process.

Chapter 1: Introduction

The Problem

Clinical Problem: Mechanical Ventilation

Every year 750,000 patients suffer from acute respiratory failure in the intensive care unit (ICU) and are invasively mechanically ventilated (Wunsch et al., 2010). Mechanical ventilation (MV) is a life-saving intervention; however, its use can cause severe iatrogenic harm. Mortality for mechanically ventilated patients is as high as 35% (Wunsch et al. 2010; Esteban et al., 2013; Mehta, Syeda, Wiener, & Walkey, 2015). In addition, patients who are mechanically ventilated have longer lengths of stay in the ICU (Penuelas et al., 2011) and are at higher risk for complications including ventilator-associated pneumonia (Rello et al., 2002), delirium (Van Rompaey et al., 2009), and ICU acquired weakness related to neuromuscular decline (Stevens et al., 2007). Receiving mechanical ventilation is also associated with long-term morbidity with a higher prevalence of cognitive impairments (Hopkins et al., 2005), physical limitations (Herridge et al., 2016), and poor quality of life (Cuthbertson, Roughton, Jenkinson, Maclennan & Vale, 2010) after ICU discharge.

Achieving rapid "liberation" from mechanical ventilation can protect patients from potential harm (Hall & Wood, 1987; Ely, 2017) and has been advocated for since the late 1980s. Yet, consistently achieving rapid MV liberation remains an elusive goal in the delivery of intensive care services. In a retrospective population-based analysis comparing trends in mechanical ventilation use between 1993 and 2009, Mehta et al. (2015) reported that the

percentage of mechanically ventilated patients who were intubated for longer than 96 hours increased from 29% in 1993 to 41% in 2009. Inconsistent delivery of liberation-driven care practices may be contributing to this trend (Miller, Govindan, Watson, Hyzy, & Iwashyna, 2015; Burns et al., 2018).

Managing mechanical ventilation and ultimately executing the decision to extubate requires a high degree of coordination and collaboration between multiple members of the patient's care team (Costa et al., 2018). Routine delivery of spontaneous awakening trials (i.e. decreasing the dose of sedation a patient is receiving to assess for alertness) (Kress, Pohlman, O'Connor & Hall, 2000) and spontaneous breathing trials (i.e. changing the ventilator settings to assess for readiness to extubate) (Ely et al., 1996) can reduce duration of mechanical ventilation and are recommended as standard practice (Barr et al., 2013; Schmidt et al., 2017). Furthermore, delivering spontaneous awakening and breathing trials concurrently can significantly reduce MV duration (Girard et al., 2008). In practice, the patient's bedside nurse, respiratory therapist, and physician all play a significant role in the delivery of these recommended care practices. The nurse provides continuous surveillance to assess the patient's readiness to wean and manages his/her sedation and analgesic medications, the respiratory therapist initiates the spontaneous breathing trial and changes the ventilator settings to meet the patient's respiratory drive, and the physician coordinates the decision-making processes (Blackwood, Burns, Cardwell & O'Halloran, 2014). Although interprofessional collaboration is a crucial component of delivering mechanical ventilation, achieving effective interprofessional collaboration in this complex care practice is difficult (Balas et al., 2013).

Issues related to interprofessional collaboration among clinicians involved in the delivery of mechanical ventilation are consistently identified as barriers to the routine use of liberation-

driven care practices (Jordan, Rose, Dainty Katie, Noyes & Blackwood, 2016; Costa et al., 2017). Based on this assessment, improving interprofessional collaboration may be one mechanism to actualize rapid liberation and improve outcomes for mechanically ventilated patients. Yet, targeted practice interventions to improve interprofessional collaboration in the delivery of complex interventions like mechanical ventilation are limited in the current literature (Dietz et al., 2014). General interventions to improve collaboration, which typically include a combination of practices such as interprofessional daily rounds, checklists, and "team training," are plentiful; however, the effects of these interventions are inconclusive (Reeves, Pelone, Harrison, Goldman, & Zwarenstein, 2017). Ultimately, this introduces a significant gap in current critical care practice—delivering complex care inherently requires a high degree of collaboration, but we do not have appropriate practice interventions to ensure effective collaboration is consistently achieved. To address these issues related to interprofessional collaboration, identifying a valid method to measure interprofessional collaboration is crucial.

Scientific Problem: Measurement Limitations for the Process of IPC

A variety of methods are identified in the literature to assess interprofessional collaboration in the intensive care setting. However, there is inconsistency between the current conceptualization and operationalization of interprofessional collaboration.

Interprofessional collaboration is described as a dynamic process consisting of interactions between clinicians as they work together to deliver care (D'Amour, Ferrada-Videla, San Martin Rodriguez, & Beaulieu, 2005). None of the current measurement approaches operationalize interprofessional collaboration as such a process. To illustrate the inconsistency, surveys are among the most commonly used methods to measure IPC to date. Surveys often ask clinicians to recall their knowledge, attitudes, and perceptions toward interprofessional

collaboration in their respective workplaces (Walters, Stern, & Robsertson-Malt, 2016; Valentine, Nembhard, & Edmondson, 2015). Surveys assume interprofessional collaboration is a fixed attribute of unit culture that can be described retrospectively; this approach does not provide a mechanism to measure the complex process of IPC. Additionally, there is considerable evidence that clinicians from different professional backgrounds consistently answer survey questions related to interprofessional collaboration differently. For example, physicians tend to report better collaboration than nurses, on average (Sollami, Caricati, & Sarli, 2015). As such, the risk for self-report bias further limits the appropriate use of surveys to measure interprofessional collaboration (Costa, Kuza, & Kahn, 2015). In addition to surveys, observational rating tools are also identified as a method to measure interprofessional collaboration. When using this approach, an external observer rates the quality of clinician interprofessional interactions based on a set of predetermined collaborative behaviors such as open communication or shared decision-making (Dietz et al.,2014). Using an external observer seemingly increases the objectivity of the tool; yet, this approach focuses on evaluating clinician performance and does not necessarily produce an objective quantification of the IPC process. Additionally, this approach assumes there is a standard quality of collaboration for which professionals should strive for, however there is no rigorous evidence supporting these claims.

One can argue that to date, there are no valid methods to measure interprofessional collaboration since the previous approaches fail to consider the quintessential processual attribute of IPC. This evident measurement limitation may be contributing to the current impasse in effective intervention development for interprofessional collaboration (Reeves et al., 2017). Aligning the conceptualization of IPC as a process with its measurement and operationalization may provide a unique solution to the current measurement problem. However, the current

healthcare literature base does provide any evidence for a method to measure IPC as such a process.

In summary, mechanical ventilation outcomes for critically ill adults are suboptimal. Interprofessional collaboration is a crucial component of effective mechanical ventilation management and delivery; yet achieving effective IPC in the delivery of this complex care practice is challenging. The literature lacks effective interventions to address issues related to interprofessional collaboration primarily due to measurement limitations. Indeed, if the process of interprofessional collaboration cannot be measured, it cannot be improved. Addressing this measurement limitation may move the needle in improving interprofessional collaboration and ultimately the outcomes for critically ill adults.

Study Overview and Aims

One way to better align the conceptualization and measurement of IPC as a process may be the use of time-motion methodology. Time-motion methodology is a validated approach historically used in industrial and operations engineering to measure and evaluate industrial processes (Lopetegui et al., 2014). When applying this method, the selected process is first broken down into a series of individual tasks (task list), then trained observers use continuous direct observation to collect data on the time it takes a qualified worker to complete the individual tasks which collectively make-up the completed process (Zheng, Guo, & Hanauer, 2011). The data collected using this approach results in an objective quantification of the observed process (Finkler, Knickman, Hendrickson, Lipkin, & Thompson, 1993). Since IPC is conceptualized as a process, applying time-motion methods to quantify the process of IPC may provide a unique solution to current measurement limitations.

This study developed a time-motion tool to measure the process of IPC specifically as it relates to the care of mechanically ventilated patients. Since mechanical ventilation is an intervention delivered at high frequency in the ICU (Wunsch et al., 2010; Wunsch et al., 2013) and requires interprofessional collaboration (Blackwood et al., 2014; Balas et al.; 2014; Costa et al., 2018) it provided a superb test-case for the current project. This tool will serve as the foundation for examining how variation in the process of IPC affects intervention delivery, decision making, and subsequently patient outcomes in future scientific work. This study built on the robust design and data from an ongoing funded study (K08-HS024552) in Michigan. The specific aims of the study were to:

Aim 1: Develop a task list for the process of interprofessional collaboration in the care of mechanically ventilated patients.

I applied both a directed and conventional content analysis to an existing set of qualitative data (observations, shadowing and clinician interviews) from 2 ICUs in 2 hospitals. These data examine interprofessional interactions to identify who, when, where, and in what ways clinicians interact to deliver care for mechanically ventilated patients. The purpose of this content analysis was to identify collaborative activities and enablers to collaborative activities to include in the final task list. Collaborative activities include behaviors that demonstrate direct engagement in the process of IPC and the enablers to collaborative activities include those behaviors clinician use to initiate or facilitate a collaborative encounter**.**

Aim 2: Determine the feasibility of using time-motion methodology to measure the process of interprofessional collaboration in the care of mechanically ventilated patients. I, along with two trained observers, collected time-motion data on the process

of IPC in the care of mechanically ventilated patients in 1 ICU. We collected the data using a time-motion tool that I developed in partnership with the Center for Healthcare Engineering and Patient Safety at the University of Michigan. The data was collected while observing clinicians involved in the care of mechanically ventilated patients (i.e. nurse, respiratory therapist, and physician). Descriptive statistics were analyzed to describe the duration and frequency at which clinicians engage in collaborative activities and enablers (from the IPC task list) while caring for MV patients.

Significance

Demand for critical care services in the United States is projected to grow as the population continues to age and the prevalence of complex chronic disease subsequently increases (Angus et al., 2000). Mechanical ventilation is one of the most commonly delivered interventions in the ICU, with up to 40% of ICU patients requiring MV, on average (Wunsch et al., 2013). And so, we can anticipate that the prevalence of mechanical ventilation will also increase in direct relation to the rise in ICU services. Caring for critically ill patients places an immense burden on the US healthcare system. It is estimated that costs related to intensive care services exceed 100 billion dollars annually or approximately 1% of the GDP (Halpern, Goldman, Tan, & Pastores, 2016). Total costs for mechanical ventilation exceed 27 billion dollars annually, or approximately one-third of intensive care costs (Wunsch et al., 2010). Thus, focusing on improving the delivery of mechanical ventilation is both a critical care priority and a public health necessity.

Many ICU interventions, in addition to mechanical ventilation, are complex and require interprofessional collaboration to be consistently and effectively delivered (Blot, Afonso, & Labeau, 2014; Donovan et al., 2018). Additional examples include sepsis resuscitation

(Palleschi, Sirianni, O'Connor, Dunn, & Hasenau, 2014) and early mobility (Dubb et al., 2016). Measuring and subsequently improving the process of interprofessional collaboration in the care of mechanically ventilated patients can inform the development of future practice interventions designed to improve the process of IPC in complex care delivery. This can ultimately lead to better health outcomes for critically ill patients and decreased costs for the entire health system.

Summary

Mechanical ventilation is one of the most frequently delivered interventions in the intensive care setting. Delivering this invasive intervention is costly and prolonged use can cause short and long-term patient harm. Critically ill patients do not consistently achieve rapid liberation from mechanical ventilation. Poor collaboration among clinicians involved in caring for mechanically ventilated patients, including the bedside nurse, respiratory therapist, and physician, may be contributing to suboptimal outcomes. Currently, there is no adequate method to measure the process of interprofessional collaboration. This measurement limitation prevents the development of interventions to improve the process of interprofessional collaboration in the delivery of complex care practices like mechanical ventilation. To address this gap, this study aimed to test the feasibility of using time-motion methodology to measure the process of IPC as it relates to the care of mechanically ventilated patients. Time-motion methodology is a validated approach used in industrial and operations engineering to measure and evaluate processes. Since IPC is conceptualized as a process, applying time-motion methods to measure the process of IPC may provide a unique solution to current measurement limitations. Measuring and improving the process of interprofessional collaboration will optimize the quality and safety of care delivery and result in better patient outcomes in critical care.

Chapter 2: Background and Significance

Medical errors contribute to thousands of patient deaths each year (James, 2013; Makary & Daniel, 2016); yet, most of these errors are preventable ("Sentinel event statistics", 2015). Failures in interprofessional collaboration and teamwork are consistently identified as contributing factors to medical errors (Pronovost et al., 2006; Pham et al., 2011; Manojlovich & DeCicco, 2007; Gawande, Zinner, Studdert & Brenna, 2003; Rogers et al., 2006). To address this issue, the National Academy and the World Health Organization have prioritized efforts to improve interprofessional collaboration and teamwork in healthcare delivery over the past two decades (Institute of Medicine, 2001; WHO, 2010; Bates & Sing, 2018). But evidence for the effectiveness of these improvement efforts is inconclusive (Zwarenstein, Goldman, & Reeves, 2009; Reeves et al., 2017). The literature reveals conceptual and methodological gaps that limit our current understanding of interprofessional collaboration in practice. The following chapter will describe how the current study bridges the gaps identified in the literature to advance the study of IPC towards improving the safety and quality of healthcare.

Definition of Interprofessional Collaboration in the Acute Care Setting

In the literature, interprofessional teamwork and interprofessional collaboration are often used interchangeably to signify effective interprofessional work. Yet, interprofessional teamwork and interprofessional collaboration are distinct concepts (Reeves, Xyrichis, & Zwarenstein, 2018). **Interprofessional teamwork** is defined as a "type of interprofessional work which involves different health and/or social professions who share a team identity and work closely

together in an integrated and interdependent manner to solve problems and deliver services" (Reeves, Lewin, Espin, & Zwarenstein, pp.45, 2010). This type of interprofessional work is characterized as a continuous concerted effort as clinicians work together to deliver patient care (Xyrichis & Ream, 2008). Conversely, **interprofessional collaboration** is defined as a "type of interprofessional work which involves different health and social care professions who regularly come together to solve problems and provide services" (Reeves, et al., pp.45, 2010). Interprofessional collaboration is described as a "looser form" of interprofessional work, in which professionals interact episodically (Reeves et al., 2018). Professionals work closely together to achieve a goal in IPC; however, these professional interactions are not prefaced by the acquisition of a shared team identity (Alexanian, Kitto, Rak, & Reeves, 2015).

Table 1
Comparing interprofessional teamwork and collaboration

Interprofessional teamwork	Interprofessional collaboration
"type of work which involves different health and/or social professions who share a team identity and work closely together in an integrated and interdependent manner to solve problems and deliver services" (Reeves, Lewin, Espin, & Zwarenstein, pp. 45, 2010)	"type of interprofessional work which involves different health and social care professions who regularly come together to solve problems and provide services" (Reeves, Lewin, Espin & Zwarenstiein, pp. 45, 2010)
Continuous, concerted effort	Episodic process

The concept of interprofessional teamwork largely prevails as the gold-standard for effective interprofessional interactions in the healthcare setting (Reeves et al., 2010) and the uptake of team training initiatives in healthcare is pervasive (Hughes et al., 2016). However, there is conflicting evidence that in the acute care and intensive care setting, interprofessional collaboration is the more commonly observed type of interprofessional work (Lingard, Espin, Evans & Hawryluck. 2004; Reeves & Lewin, 2004; Lewin & Reeves, 2011; Piquette, Reeves, &

Leblanc, 2009; Paradis et al., 2014, Alexanian et al., 2015; Xyrichis, Reeves & Zwarenstein, 2017). In these unique settings, the clinicians involved in patient care can vary shift by shift and day by day (Bleakley, 2013). Additionally, the goals of care constantly change as patient conditions rapidly evolve (Ervin, Kahn, Cohen & Weingart, 2018). Due to this inherent instability, the actualization of teamwork in these settings may be infeasible (Reader & Cuthbertson, 2011). To be most representative of clinical practice in the ICU, this dissertation projects focuses specifically on the concept of interprofessional collaboration.

To ensure conceptual clarity, interprofessional collaboration is conceptualized as: a process composed of episodic interpersonal interactions during which clinicians integrate their professional skills and knowledge to make a clinical decision or attain a patient centered goal (Alexanian et al., 2015; Baggs & Schmitt, 1997; D'Amour et al., 2005; Hawryluck, Espin, Garwood, Evans, & Lingard, 2002; Henneman, Lee, & Cohen , 1995; Lewin & Reeves, 2011; Lingard, et al., 2004; Reeves & Lewin, 2004; Reeves et al., 2017; Rose, 2011; Xyrichis et al., 2017). The process of interprofessional collaboration can further be specified based on clinical context. For example, the purpose of this project was to examine the process of interprofessional collaboration in the care of mechanically ventilated patients. In this specific clinical context, the process of interprofessional collaboration is composed of episodic interpersonal interactions between the bedside nurse, respiratory therapist, and physician (Ely et al., 2001; Costa et al., 2018). During these interactions, the respective clinicians integrate their knowledge and skills to advance the patient towards rapid liberation from the ventilator and eventual stabilization. The processual nature of interprofessional collaboration has implications for how we should study this phenomenon. Indeed, the conceptualization of interprofessional collaboration as a process

informed the development of the guiding conceptual framework described in the following section.

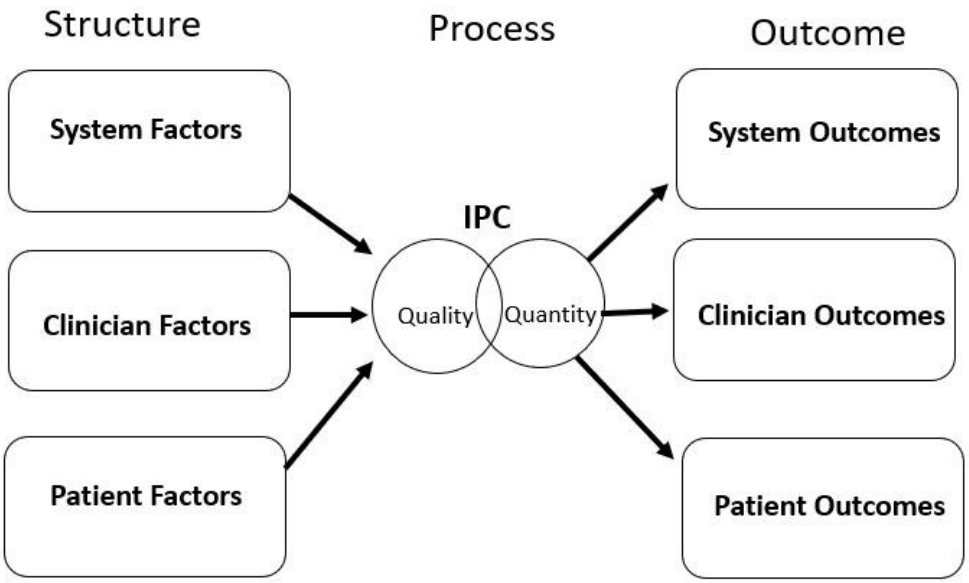
Conceptual Framework

The conceptual model guiding the proposed research is informed by Donabedian's traditional structure-process-outcome model (Donabedian, 1978). The original framework was developed by Donabedian to evaluate quality of care in the healthcare system. The central assumption of this model is that "good structure increases the likelihood of good process, and good process increases the likelihood of a good outcome" (Donabedian, 1988). Traditionally, structural factors include those "material and social instrumentalities" that influence the provision of care processes (Donabedian, 1978). Processes mediate the relationship between structure and outcome and include those activities directly involved in the delivery of care. In the original model, Donabedian distinguishes care processes based on technical and interpersonal attributes. Technical attributes of care relate to providers' abilities to competently deliver care by using the skills acquired in their professional training in accordance with established policies and procedures. Interpersonal attributes of care relate to providers' abilities to communicate and collaborate with other key stakeholders in care delivery including the patient and other members of the care team (Donabedian, 1988). Outcome is the third construct in the model and is operationalized as the variable that changes as a result of the care processes provided (Donabedian, 1978). Based on Donabedian's distinction between technical and interpersonal attributes of care processes, interprofessional collaboration can be classified as an interpersonal care process and fits logically and consistently into the structure-process-outcome model.

A graphical representation of the interprofessional collaboration framework model is included in **Figure 1**. A concept analysis was conducted using the strategies outlined by Walker

and Avant to identify the defining attributes, antecedents, and consequences of the IPC process (Walker & Avant, 2011). This preliminary work informed the development of the conceptual framework for Interprofessional Collaboration (IPC) in the acute-care setting. Interprofessional collaboration is depicted as the central process characterized by quality and quantity. As illustrated in the model, it is assumed that the quality and quantity of IPC interact to yield the primary outcomes. Quality is determined by the appropriateness and effectiveness of interprofessional interactions as clinicians work together to attain a patient centered goal. Quantity is defined by the duration and frequency of those interprofessional interactions. Examining both the quality and quantity of interprofessional collaboration will support the most comprehensive understanding of IPC. In the adapted model, the structure and outcome constructs are further classified into 3 sub-constructs: system, clinician, and patient. This demonstrates the range of factors that can affect the process of IPC and signifies its potential to influence pertinent system and clinician outcomes in addition to the traditionally examined patient outcomes.

Figure 1 Conceptual Framework for Interprofessional Collaboration (IPC)



To examine the relationships identified in the model above, identifying valid and reliable methods to operationalize the specific constructs is critical. Though interprofessional collaboration is identified as a process, it is not operationalized as a process in the current literature. The underlying motivation of the current research project is the hypothesis that aligning the measurement and conceptualization of interprofessional collaboration as a process will address some of the limitations in the current literature, outlined in the following section.

Review of the Literature

The current research project was set in the intensive care setting. The staffing and organizational design of intensive care units create a unique environment to examine the process of interprofessional collaboration. ICUs are separate units within the healthcare system where care is provided to critically ill patients. The ICU itself typically uses an open layout to facilitate close monitoring of critically ill patients. ICUs are also often staffed by unit-based nurses, physicians, and allied health personnel to ensure all professionals involved in patient care are in close proximity. This allows easy accessibility and rapid response to changes in patient condition (Brilli et al., 2001). Due to these unique structural features, the ICU is a relatively contained environment to assess interprofessional interactions compared to other units in the acute care setting. The complex needs of the patients being cared for in the ICU also influence the nature of interprofessional interactions in this setting. Patients in the ICU represent those with the highest severity of illness among hospitalized patients and managing their complex conditions inherently requires more collaboration among clinicians (Blot et al. 2014; Manthous & Hollingshead, 2011). Indeed, observational data provides evidence that the frequency of interprofessional interactions is higher in the ICU compared to general acute care units (Ballermann, Shaw, Mayes, Gibney, & Westbrook, 2011; Gonzalo, Himes, McGillen, Shifflet, & Lehman, 2016). Based on these

characteristics, the ICU provides an exceptional setting to test the feasibility of the novel application of time-motion methodology to measure the process of interprofessional collaboration.

For consistency, the following literature review focuses exclusively on the intensive care setting. This review will be organized using the constructs identified in the conceptual model. The first section will summarize the literature on structural factors that influence IPC in the ICU, followed by a discussion describing how interprofessional collaboration is assessed in the ICU to date, and lastly the review will present the current evidence surrounding the relationship between interprofessional collaboration and outcomes in the ICU. I will then review the state of the science on time-motion methods as an opportunity to quantify healthcare processes. The review summarizes gaps in the current literature and describes how the current project addresses these gaps.

Structural Factors Influencing IPC in the ICU

Structural factors theoretically facilitate or inhibit the process of interprofessional collaboration in the ICU. There are three structural factors identified in Figure 1 and they include system factors, clinician factors and patient factors.

System Factors

System factors include organizational characteristics such as culture, work environment, quality of leadership, uptake of information technology, and implementation of specific policies and protocols that can influence the IPC process (Mitchell, Ferketich, & Jennings, 1998; Shortell, Rousseau, Gillies, Devers, & Simons, 1991). Beginning with culture, embracing a culture of safety is believed to be fundamental to achieving effective collaboration in an organization. Specifically, safety culture is defined as the "values, attitudes, perceptions,

competencies, and patterns of behavior" that demonstrate an organization's commitment to safety (Nieva & Sorra, 2003). Parsing out the effects of safety culture on collaboration is difficult because these variables are often described as interdependent concepts in the literature; however, there is some evidence suggesting that targeted efforts to improve safety culture can have positive effects on collaboration. Pronovost and colleagues (2008) conducted a study to evaluate the effects of the comprehensive unit-based safety program (CUSP) on ICU outcomes in hospitals participating in the Keystone collaborative. After implementing the CUSP in 99 ICUs, the investigators found that using an organized approach to improve ICU safety culture increased clinician's perceived quality of teamwork, on average. Complementary to safety culture, positive work environments, characterized by workplace empowerment and support for professional practice and autonomy, is also associated with clinicians' perceptions of interprofessional collaboration in the ICU (Manojlovich & DeCiccco, 2007; Papathanassoglou et al. 2012).

Leadership plays a crucial role in the development of supportive, or unsupportive, cultures and work environments and so leadership qualities can also influence IPC. For example, if leaders advocate for and prioritize collaborative work, this can motivate staff to engage in IPC (Henneman et al., 1995; Reeves et al., 2010). Reader and colleagues distributed a survey to ICU nurses and physicians working in four different hospitals in the UK and found that clinicians' perceptions of unit leadership significantly predicted their perceptions of open communication in the ICU (Reader, Flin, Mearns & Cuthbertson, 2007). In a subsequent study, Reader and colleagues interviewed 25 intensive care senior physicians who are often designated as clinical leaders within the ICU unit. The investigators describe how the use of different leadership behaviors by senior ICU physicians such as providing team direction, information gathering from pertinent team members and consistently adhering to protocols, can facilitate overall ICU

team performance (Reader, Flin, & Cuthbertson, 2011). Together these studies suggest that individuals in leadership positions may be partially responsible for how collaboration is actualized in practice.

Other, perhaps more tangible, system factors that influence collaboration include technology and implementation of specific policies and procedures. Information technology is becoming increasingly more common in healthcare delivery and it's use influences the mechanisms by which clinicians communicate with one another. In two separate interview studies with ICU clinicians, information technology (IT) was described as both a potential facilitator and barrier to collaboration. IT can increase clinician's access to information and potential to identify errors (Costa, Barg, Asch, & Kahn, 2014); however, its use can also reduce face-to-face interactions which clinicians perceive as problematic (DeKeyeser Ganz, Engelberg, Torres, & Curtis, 2016). Attempts to standardize collaboration by instituting certain policies like structured daily interprofessional rounds also influence clinician perceptions of interprofessional collaboration in the ICU (Centofanti et al., 2014). Pronovost and colleagues (2003) are credited for introducing the benefits of instituting a daily goals form—essentially a checklist for ICU patient needs—to facilitate collaboration in morning rounds. In a single site, pre/post study, the investigators found that after instituting the protocol, the percentage of nurses and residents who reported they understood their patients' daily goals increased substantially from 10 to 95%. In response, checklists have been widely adopted by many ICUs, however the actual implementation of checklists in practice is variable (Hallam et al., 2018). When used, clinicians do report that they help with establishing a shared understanding (Centofanti et al., 2014; Hallam et al., 2018), however inconsistent use makes it difficult to conclude any definitive effects.

The described relationships between system factors and IPC are preliminary as this body of evidence is largely composed of exploratory study designs including cross-sectional survey studies and qualitative studies. In addition, it is important to note that there are likely other system factors that influence IPC which have yet to be examined. Other organizational characteristics, like teaching status, may influence the skill mix and demographics of clinicians involved in care delivery and inherently affect IPC. Additionally, there is a substantial body of evidence examining the effects of clinician staffing on ICU outcomes, but no study to date has examined the direct effects of staffing on IPC (Kelly, Kutney-Lee, McHugh, Sloane, & Aiken, 2014; Costa, Wallace, Barnato, & Kahn, 2014; Costa, Wallace & Kahn, 2015; Kerlin et al., 2017; Wallace, Angus, Barnato, Kramer, & Kahn, 2012). Staffing patterns may affect clinician's availability to engage in IPC and would also be interesting to examine in future work. As previously described, interventions to improve interprofessional collaboration in the delivery of complex interventions in the ICU are limited. Understanding the effects of system factors on interprofessional collaboration will likely play a significant role in future intervention development, implementation, and sustainability. And so, the body of evidence describing system factors that affect IPC should be expanded in future work.

Clinician Factors

As described in the conceptual definition for interprofessional collaboration, clinician interactions represent the key mechanism underlying the process of IPC. Thus, it stands to reason that certain clinician characteristics can influence the process of collaboration. Indeed, evidence pooled from a sample of cross-sectional studies suggests there is variation in perceived quality of collaboration based on professional affiliation. Specifically, nurses and physicians seem to consistently rate the overall quality of teamwork and collaboration, as well as specific

components such as the boundedness of the team or timeliness and openness of communication, differently (Adler-Milstein, Neal, & Howell, 2011, Thomas, Sexton, & Helmreich, 2003, Reader et al., 2007). Aside from professional roles, there is descriptive evidence that generally, ICU clinicians have varying beliefs and attitudes towards the value of interprofessional collaboration (Kydona, Malamis, Giasnetsova, Tsiora, & Gristi-Gerogianni, 2010; Van den Bulcke et al., 2016) which could ultimately affect their IPC behavior. Furthermore, exhibiting more favorable traits can also influence clinician participation in IPC. Clinicians describe wanting to collaborate with individuals who they perceive as knowledgeable, accessible, and respectful (Baggs & Schmitt. 1997; Costa et al., 2014; Goldman, Kitto, & Reeves, 2018) and so failure to convey these qualities may decrease clinician engagement in the IPC process.

The described differences in clinician perception towards interprofessional collaboration may be the result of professional training and socialization (Hall, 2005). In theory, integrating interprofessional education into health professional programs may be a way to minimize the effects of clinician factors on IPC; however, interprofessional education can be challenging to implement (Lawis, Anson, & Greenfield, 2014). Furthermore, differences in IPC engagement may be due to inherent differences in individual clinician personalities which are not necessarily modifiable. Therefore, clinician characteristics should not be ignored when describing the nature of IPC. In addition, it is important to note that much of the evidence exploring clinician factors and IPC focuses exclusively on the nurse-physician dyad. One can anticipate that considering factors related to other clinicians involved in patient care in the ICU including respiratory therapists, physical therapists, and social workers, to name a few, would introduce additional complexity in understanding how clinician factors influence the process of IPC in the ICU. Thus,

similar to systems factors, further work is needed to generate a more comprehensive understanding of the effects of clinicians factors on collaboration in the ICU.

Patient Factors

Since the purpose of interprofessional collaboration is to integrate professional skills and knowledge to make a clinical decision or attain a patient centered goal, it stands to reason that patient factors will also influence the process of IPC. Patient factors can further be described as state or trait characteristics (Radwin & Fawcett, 2002). State characteristics refer to patient characteristics which can change over the course of the patient's care trajectory, such as severity of illness. Conversely, trait characteristics include stable characteristics which are not likely to change during a patient care encounter such as demographic characteristics (Radwin & Fawcett, 2002). Currently, there is no quantitative evidence in the literature demonstrating a relationship between distinct state or trait patient characteristics and interprofessional collaboration in the ICU. However, there is qualitative evidence illustrating that the nature of IPC fluctuates based on patient needs (Hawryluck et al., 2002; Xyrichis et al., 2017) and that the intensity of IPC appears to increase in patient crisis situations and lessen following stabilization (Piquette et al., 2009). Patient needs likely establish the criteria for the quality (i.e. the appropriateness) as well as the quantity of interprofessional collaboration needed in the ICU. Among structural factors, the influence of patient factors on interprofessional collaboration is the least explored. Expanding this evidence base may help us understand the factors that motivate clinicians to engage in the IPC process.

In summary, the literature presents many confounding system, clinician, and patient factors that may influence interprofessional collaboration in the ICU. The majority of studies summarized above report using qualitative methods or a cross-sectional survey design to explore

the proposed relationships between structural factors and IPC. And so, this is, at best, a developing body of evidence. Knowing the independent and multifaceted effects of system, clinician, and patient factors on the process of interprofessional collaboration in the ICU will critically inform the implementation of future practice interventions designed to improve IPC in complex care delivery. And so, future work should continue to focus on the rigorous investigation of structural factors that both facilitate and inhibit the process of IPC in the ICU.

Assessing IPC in the ICU

Various methods are used to assess interprofessional collaboration in the ICU in the extant literature. The following section will summarize the different methods described in the literature organized by study design: qualitative, quantitative, observational rating tools, and multi-methods. The review will focus primarily on the limitations of these respective methods. To be as comprehensive as possible, studies describing both teamwork and interprofessional collaboration were included since these terms are used interchangeably in the current literature.

Qualitative Studies

Qualitative studies examining interprofessional collaboration in the ICU, while unable to measure the process of IPC, provide insights into the complexities embedded in the process. These studies focus on answering very specific research questions related to the process of IPC and often use ethnographic approaches or semi-structured interviews to gather this knowledge. Example research questions in this body of work include: how is interprofessional work carried out in the ICU setting (Alexanian et al., 2015), how do clinicians view IPC in the ICU (Costa et al., 2014), what factors influence collaborative processes (Bjurling-Sjöberg, Wadensten, Poder, Jansson, & Nordgren., 2017), what is the perceived quality of interprofessional interactions in

different clinical scenarios like medical crises and rounds (Paradis, Leslie, & Gropper, 2016; Piquette, et al., 2009a; Piquette, Reeves, & Leblanc, 2009b), and even how are families incorporated into collaborative decision-making (Reeves et al., 2015)? These studies were conducted in diverse settings – nationally and internationally – and in medical, surgical, cardiac and other ICUs (See Table 2 on a following page).

Despite small sample sizes common in qualitative work and concerns regarding generalizability, the robust sample of qualitative studies, described in Table 2, supports the conceptualization of interprofessional collaboration as a dynamic process that occurs episodically in practice (Alexanian et al., 2015; Bjurling-Sjoberg et al., 2017; Costa et al.,2014; Paradis et al., 2016; Reeves et al., 2015). Furthermore, the process of collaboration appears to fluctuate based on clinical context with distinct differences in the nature of interprofessional interactions when comparing routine work to urgent crisis situations (Piquette et al., 2009; Xyrichis et al., 2017). The qualitative literature also provides further insight into the interpersonal aspect of IPC, exploring how factors like trust (Costa et al., 2014; Alexanian et al., 2015; Kendall-Gallagher, Reeves, Alexanian, & Kitto, 2016), respect (Kendall-Gallagher et al., 2016; Goldman et al., 2018), and power dynamics (Bjurling-Sjoberg et al., 2017; Kendall-Gallagher et al., 2016) influence how clinicians engage in the process of IPC. Across these studies, clinicians similarly describe that cultivating respect for and value of each other's roles and contributions can promote meaningful collaboration; conversely, mistrust and persisting power dynamics can cause tension and decrease clinicians' willingness to participate in IPC (Costa at al., 2014, Bjurling-Sjoberg et al., 2017; Kendall-Gallagher et al., 2016; Goldman et al., 2018). The described clinical and contextual factors likely contribute to variation in the IPC process. Recognizing that contextual and clinical factors constantly fluctuate in the ICU, this

work also implies we cannot make absolute assessments of collaboration based on single observations. In summary, the qualitative literature provides descriptive evidence for the dynamic nature of IPC in the ICU which further substantiates the need to develop a valid method to quantify dynamic interprofessional interactions.

Table2

Qualitative Studies Assessing IPC in the ICU

Author	Question/Objective	Methods	Participants	Setting
Alexanian	"Does the definition of teamwork that is so often taken a priori structure how work is carried out in the ICU setting?"	Ethnography, interviews	Staff nurses, respiratory therapists, physical, occupational, speech therapists, physicians, dietician, social worker	Two medical-surgical ICUs, one in US and one in Canada
Bjurling-Sjöberg	"...describe and explain teamwork and factors that influence team processes in everyday practice in ICU"	Focus groups	Staff nurses, physical, occupational, speech therapists, physicians, nursing assistants	One medical/cardiac ICU in Sweden
Costa	"How do ICU clinicians view IPC in the ICU and identify elements that facilitate IPC"	Interviews	Staff nurses, nurse managers, respiratory therapists, pharmacists, dieticians, physicians	Seven medical and mixed medical/surgical ICUs in US
Goldman	"...study of interprofessional collaboration in an ICU, which analyzed data by using these [CIHC and IPEC] interprofessional competency frameworks to explore their application to actual practice..."	Ethnography, interviews	Staff nurses, nursing leadership, respiratory therapists, physicians, physical therapists, pharmacists, social work, spiritual care, dietitian, patient care tech	One closed medical/surgical ICU in Canada
Kendall-Gallagher	"...a focused analysis of ICU nurses' perspective of factors that enhance or impede their interprofessional work..."	Interviews	Staff nurses	Eight medical/surgical ICUs in US and Canada
Paradis	"What were the factors influencing the conduct of interprofessional rounds and their ability to enable collaborative, patient-centered care?"	Participant observation, shadowing and interviews	Staff nurses, nurse mangers, pharmacist, physicians, physician assistants and family members	Four ICUs in US (specialty not specified)

Piquette [a]	"…to gain a deeper understanding of the perceived nature and quality of interprofessional interactions during medical crises…defined as events requiring the immediate intervention of multiple ICU team members to respond to a patient's acute instability"	Interviews	Staff nurses, respiratory therapists, physicians	Four mixed, medical/surgical, trauma and cardiac ICUs at a single health center in Canada
Piquette [b]	"What are the stressors encountered by healthcare professionals during ICU medical crises?" AND "Under which circumstances are these stressors most likely to affect individual or team performance?"	Interviews	Staff nurses, respiratory therapists, physicians	Four mixed, medical-surgical, trauma, and cardiac ICUs at a single health center in Canada
Reeves	"…explore the culture of collaboration and family member involvement…"	Ethnography, interviews	Staff nurses, pharmacists, physicians, social workers	Four ICUs in US (specialty not specified)
Xyrichis	"…examined health professional work in ICUs in the context of Department of Health policies for the modernisation of the ICU workforce."	Ethnography, interviews	Staff nurses, nurse managers, physicians, physical therapists, pharmacists	Three ICUs in UK (specialty not specified)

Quantitative Studies

Quantitative studies assessing interprofessional collaboration in the ICU frequently use survey instruments to measure interprofessional collaboration. There are over 30 survey instruments to measure interprofessional collaboration in the healthcare setting (Valentine et al., 2015). In the ICU specifically, The Safety Attitudes Questionnaire (SAQ) is the most commonly used instrument (Chaboyer et al., 2013; France et al., 2010; Meurling, Hedman, Sandahl,

Fellander-Tsai, & Wallin, 2013; Pronovost et al., 2008; Writing Group for the CHECKLIST-ICU Investigators and the Brazilian Research in Intensive Care Network (BRICNet) et al., 2016). The SAQ is a 30-item validated self-reported questionnaire that examines staff perceptions of safety climate. It has six subscales including teamwork climate, job satisfaction, perceptions of management, safety climate, working conditions, and stress recognition (Sexton et al., 2006). The SAQ is also reported as the most commonly used survey to quantify collaboration in other settings like the operating room (Li et al., 2018). Cross-sectional descriptive studies report using the SAQ instrument to describe and compare safety climate across intensive care units (Chaboyer et al., 2013; France et al., 2010). Additionally, studies aiming to examine the effects of safety interventions, including the CUSP and CHECKLIST-ICU, on perceptions of teamwork, also report using the SAQ (Pronovost et al., 2008; Writing Group for the CHECKLIST-ICU Investigators and the Brazilian Research in Intensive Care Network (BRICNet) et al., 2016). Inarguably, interprofessional collaboration and safety climate are related concepts; however, interprofessional collaboration is considered to be a uniquely complex care process (Rose, 2011; Xyrichis et al., 2017). Measuring IPC as an aspect of safety climate, opposed to as an independent concept, makes it difficult to discern the exact mechanisms by which the process of IPC affects subsequent system, clinician, and patient outcomes in the ICU. This ultimately hinders the development of effective interventions designed to improve the process of IPC, specifically.

Though not used as frequently in the current literature, other survey instruments developed to specifically measure interprofessional collaboration in the ICU exist (**Table 3**). Examples include Shortell's ICU Nurse-Physician Questionnaire (Shortell et al., 1991), Bagg's Collaboration and Satisfaction about Care Decisions (Baggs, 1994), and Weiss's Collaborative

Practice Scale (Weiss & Davis, 1985). Studies using these instruments similarly aimed to examine nurses' and physicians' knowledge and attitudes towards specific dimensions of interprofessional collaboration including communication, coordination, professional recognition, shared decision-making, and cooperative problem solving (Adler-Milstein et al., 2011; Le Blanc, Schaufeli, Salanova, Llorens, & Nap, 2010). However, by only focusing on the nurse—physician dyad, these instruments provide a limited understanding of the more inclusive process of interprofessional collaboration in the ICU.

Table 3

Quantitative Studies Assessing IPC in the ICU

Author	Instrument	Dimensions	Psychometrics	Participants
Adler-Milstein	Combination of Scales from Team Diagnostic Survey, ICU Nurse-Physician Questionnaire, Collaboration and Satisfaction About Care Decisions, and Reflexivity in Teams Surveys; 38 items total; seven-point Likert scale	1) Real team 2) Communication Quality 3) Collaborative decision-making 4) Coordination	Content Validity: Cognitive interviewing with ICU leaders Construct validity: Exploratory factor analysis (FL>0.45) Internal consistency: Cronbach's alpha (>0.72 for all subscales)	Staff nurses, residents
Writing Group… BRICNet	Safety Attitudes Questionnaire-Brazilian-Portuguese version; 36 items; five-point Likert scale	1) Teamwork climate 2) Safety climate 3) Job satisfaction 4) Stress recognition 5) Perceptions of hospital management 6) Working conditions	Not specified	ICU Staff, distribution not specified
Chaboyer	Safety Attitudes Questionnaire-ICU Version, 30 items; five-point Likert scale	1) Teamwork climate 2) Safety Climate 3) Job satisfaction 4) Stress Recognition 5) Perceptions of Hospital Management 6) Working Conditions	Construct Validity: Confirmatory factor analysis (results not reported) Internal Consistency: Cronbach's alpha (0.65-0.81 for subscales)	Staff nurses, nursing leadership, physicians
France	Safety Attitudes Questionnaire-ICU Version, 30 items; five-point Likert scale	1) Teamwork climate 2) Safety Climate 3) Job satisfaction 4) Stress Recognition 5) Perceptions of Hospital Management 6) Working Conditions	Not specified	Staff nurses, nurse managers, physicians, pharmacists, allied health professionals and care partners

Le Blanc	Combination of Scales from ICU Nurse-Physician Questionnaire and Collaborative Practice Scale; 22 items; five-point Likert scale	1) Open communication 2) Cooperative problem solving 3) Professional recognition 4) Team commitment - identification with ICU) 5) Team commitment-emotional attachment to ICU	Construct validity: confirmatory factor analysis (FL>0.49) Internal consistency: Cronbach's alpha>0.70	Staff nurses
Meurling	Safety Attitudes Questionnaire; 64 items; five-point Likert scale	1) Teamwork climate 2) Safety Climate 3) Job satisfaction 4) Stress Recognition 5) Perceptions of Hospital Management 6) Working Conditions	Internal consistency: Cronbach's alpha Pre-simulation intervention (0.43-0.71) Post-simulation intervention (0.61–0.75)	Staff nurses, nursing assistants, physicians
Pronovost	Teamwork climate scale from SAQ		Construct: confirmatory factor analysis (results not reported) Internal consistency: Cronbach's alpha=0.76	ICU Staff, distribution not specified

While there is psychometric evidence supporting the validity and reliability of the aforementioned survey instruments (Adler-Milstein et al., 2011; Chaboyer et al., 2013; Le Blanc et al., 2010; Pronovost et al., 2008), the conceptualization of IPC as a dynamic process is not adequately operationalized using survey methodology. Surveys collect clinicians' knowledge, attitudes, and perceptions of interprofessional collaboration in retrospect and assume IPC is a fixed variable that can be measured at the unit level. The breadth of literature describing interprofessional as an episodic process challenges this assumption and provides a compelling argument against the use of survey methodology to measure the uniquely complex process of IPC. Additionally, surveys are prone to self-report and recall bias (Costa et al., 2015) and can be limited by other factors such as low response rates. Furthermore, there is substantial evidence

that nurses and physicians consistently report different responses on surveys of interprofessional collaboration, with physicians perceiving collaboration to be better than nurses, on average (Adler-Milstein et al., 2011; Sollami et al., 2015). The potential confounding effects of professional biases limits the utility of self-report measures for IPC. Developing objective methods to measure the process of IPC are needed to overcome such limitations.

Observational Rating Tools Studies

Observational rating tools provide a method to rate the quality of clinician interactions which are integral to the IPC process. The underlying assumption when using observational rating tools is that when clinicians engage in interpersonal interactions related to IPC, they demonstrate distinct behaviors that are recognizable to an external observer. Generally, observational rating tools consist of a list of predetermined overt behaviors that demonstrate collaboration or teamwork. Each behavior item is paired with a response scale to rate the behavior (Dietz et al., 2014). Response scales can range from a simple binary, behavior observed or not, (Costa et al., 2016) to an ordinal scale with each increment indicating a higher or lesser quality of behavior observed (Healey, Undre, & Vincent, 2004). Observational rating tools are typically developed for specific clinical scenarios because the anticipated behaviors and nature of IPC may vary based on clinical context. When applying this method, observers monitor clinician interactions over a designated time frame and use the tool to collect data on the occurrence of the expected behaviors and the perceived quality of the observed behaviors (Dietz et al., 2014). Observational tools may be more objective than surveys because their use circumvents the self-report bias found in survey data. However, using observational rating tools also assumes there is a gold standard for collaboration behaviors which is limiting.

There are a few examples of observational rating tools to assess interprofessional collaboration among critical care clinicians (see **Table 4**). In general, most observational rating tools are applied in simulation training environments. The overreliance of observational rating tools in simulation, however, limits their utility in assessing interprofessional collaboration in clinical practice (Dietz et al., 2014). Frengley et al. (2011) developed an observational rating tool, the Teamwork Behavioral Rater (TBR), to assess teams of critical care physicians and nurses participating in simulations focused on managing airway and cardiovascular emergencies. The TBR is a 23-item observational rating tool with three subscales-- Leadership and Team Coordination, Verbalizing Situational Information, and Mutual Performance Monitoring. Each item is rated on a seven-point Likert scale (undesirable-desirable behavior). Three external observers, a critical care specialist and two anesthesiologists with critical care experience, used this tool to rate team performance for 40 separate teams, composed of three nurses and one physician each, before and after participation in a one-day team training education program. Frengley et al. (2011) report evidence for the construct validity and reliability of the TBR in the simulation setting.

Observational rating tools in clinical practice are limited, with only two identified in the ICU. Costa et al. (2016) developed and used an observational rating tool to assess interprofessional interactions around delivery of the complex Awakening and Breathing Coordination, Delirium, and Early Exercise/Mobility Bundle (ABCDE). The ABCDE bundle is recommended to manage the care of mechanically ventilated patients in the ICU. Coordinating the delivery of this multicomponent bundle requires collaboration between the bedside nurse, respiratory therapist, physician, physical therapist, and pharmacist (Balas et al., 2013). Costa et al. (2016) created a 15-item observational rating tool. For each component of the ABCDE

bundle, observers collected data via the structured tool on the following items: if the individual component was addressed, what clinician initiated the bundle component, and what other clinicians participated in the interaction. Two observers, a PhD prepared nurse with critical care experience and a graduate nursing student, piloted the tool while observing rounds in a medical ICU at an urban academic hospital. This tool showed evidence for reliability for four of the five bundle components, with poor reliability in identifying clinician interactions for the awakening component of the bundle.

Table 4

Observational Rating Tools Assessing IPC in the ICU

Author	Tool	Dimensions	Psychometrics	Participants	Duration of obs.	Observation context
Costa	Observational rating tool for ABCDE; 15 items to record observations on	For each component of ABCDE, observers recorded: if it was addressed (yes/no), the team member who initiated the interaction about ABCDE, and the other team members who participated	Content validity: Incorporated feedback from ICU clinicians in tool development Reliability: Analyzed interrater reliability using Cohen's kappa statistic Kappa for agreement re: ABCDE component addressed ranged from k= -0.07 to 0.78; kappa for agreement re: who initiated ABCDE component ranged from k=0.05 to 0.40	Staff nurses, physicians, respiratory therapists, pharmacists, and physical therapists	Observed morning rounds (approx. 3-4 hours) 1 day a week, selected at random over a month	Rounds
Dietz	Observation rating tool for Team performance; 10 specific items grouped within 4 dimensions of teamwork; five-point Likert scale; option for not applicable	Communication, leadership, backup and supportive behavior, team decision making	Reliability: Single score ICC (rounds-0.69, handoffs-0.64, simulated codes-0.62); Average ICC (rounds-0.81, handoffs-0.78, simulated codes-0.76)	Not explicitly stated	138 instances of team-work; time not specified	Rounds, nurse-to-nurse handoff, simulated code videos
Freng-ley	Teamwork Behavioral Rater; 23 items; seven-point Likert scale to evaluate undesirable to desirable behavior	Leadership and team coordination, Verbalizing situational information, mutual performance monitoring	Exploratory factor analysis for tool validity: FL>0.40 Internal Consistency Cronbach's alpha (0.89-0.92)	Staff nurses, physicians	Observed 160 sims, each lasting approx. 15 minutes	Cardiac and airway emergency simulations

Dietz and colleagues (2018) developed an observational rating tool to assess teamwork generally in the ICU. The 10-item tool has four dimensions—communication, leadership, backup and supporting behavior, and team decision-making. Each item is rated on a five-point Likert scale ranging from (1) poor to (5) very effective. Raters can also select 'not applicable' if the

teamwork competency is perceived as not relevant to an observed task. The investigators applied the tool in both clinical (morning rounds and nurse-to-nurse report) and simulated instances of teamwork (codes). The tool was deployed by two researchers who are experts in human factors engineering. Overall, there was evidence for 'good' interrater reliability; however there appears to be variability based on the task observed. For example, the ICC between the two observers for the contingency planning behavior under the team decision-making dimension was 0.47 when observing hand-offs, compared to 0.58 for rounds and "not applicable" during simulated codes. Additionally, the ICC for communication style was 0.75, 0.64, and 0.38 respectively when comparing rounds, hand-offs, and simulated codes. Recognizing that the team tasks observed are heterogeneous, variable reliability for certain items on the tool when comparing different clinical contexts seems to limit the generalizability of the developed tool.

There are identified strengths in using observational rating tools to assess collaboration and teamwork in the ICU. Compared to survey methodology, which relies on retrospective recall, these tools can provide a more accurate assessment of interprofessional collaboration by using direct observation to collect data on interprofessional interactions as they occur in real time. Additionally, using external observers to collect data on overt behaviors enhances the objectivity of this measurement approach. However, there are also apparent limitations with using this approach to assess IPC. First, these tools are criticized for having low temporal resolution (Dietz et al., 2014). That is, a single score is selected for the identified behaviors over the entire observation period and so the tool is not sensitive to changes in behavior that may yield important insight into the dynamic nature of the interprofessional team encounter. In addition, observational rating tools are primarily developed to evaluate the performance of clinicians, focusing almost exclusively on examining the quality of interprofessional

collaboration. As a result, these tools do not provide a quantification for the process of IPC and cannot ultimately be used to examine the effects of variation in the IPC process on subsequent system, clinician, and patient outcomes. Because these tools focus on evaluating the quality of interprofessional interactions, they typically rely on trained experts to adequately apply the tool. Additionally, using observational rating tools can be labor intensive. A combination of these characteristics limits the usability and generalizability of applying observational rating tools to measure collaboration in ICU practice.

Multi-Methods Studies

Due to the identified limitations of qualitative, quantitative, and observational rating tools for assessing interprofessional collaboration, some work describes using multiple methods to evaluate interprofessional collaboration in the ICU. Dekeyser-Ganz et al. (2016) describe a multi-method study they conducted to develop a conceptual model for how clinicians engage in shared decision-making in the delivery of intensive care services. The investigators first administered the Jefferson Scale toward Physician-Nurse Collaboration, a 15 item self-reported survey with six subscales—responsibility, expectations, shared learning, decision-making, authority, and autonomy—to a sample of 125 ICU nurses and physicians and then conducted observations and interviews with 42 of these clinicians. Holodinsky et al. (2015) used a similar approach, administering surveys and conducting interviews with ICU clinicians to assess the quality of interprofessional rounds in the ICU. Specifically, the investigators administered the National Survey of ICU Patient Care Rounds, a 38 item self-reported survey with nine subscales including interprofessionalism, goal development, and perceptions of open and collaborative environments, to 111 medical directors and nurse managers. The investigators also conducted follow-up interviews with seven participants who completed the survey. Both of these studies

reportedly aimed to generate a more comprehensive understanding of clinicians' perceptions of IPC by using more than one method to gather data. Please see Table 5 for details of these studies.

Table 5

Multi-methods Studies Assessing IPC in the ICU

Author	Methods	Survey instrument	Dimensions of instrument	Psycho-metrics	Duration of obs. + context	Participants
Dekeyser Ganz	Survey, observa-tions, and interviews	Jefferson Scale toward Physician-Nurse Collaboratio n; 15 items; four-point Likert scale	1) Responsibility 2) Expectations 3) Shared learning 4) Decision making 5) Authority 6) Autonomy	Report previous Cronbach alpha of 0.84 and 0.85 for medical and nursing students (not sample)	1 to 3 months; General interactions on unit and rounds, code teams, and family meeting	Staff nurses, physicians
Holodinksy	Survey, interviews	National Survey of ICU Patient Care Rounds; 38 items; combination of Likert scales, ordinal scales and open- ended questions	1) Interprofessionalism 2) Standard time/location 3) Defined roles 4) Tools to facilitate rounds 5) Interruptions 6) Goal development 7) Patient-centeredness 8) Efficiency 9) Open and collaborative environment	Not specified	n/a	Medical directors, physicians, nurse managers, patient care coordinators

Author	Methods	Survey instrument + psycho-metrics	Observational rating tool + psychometrics	Duration of obs.	Context	Participants
Kemper	Surveys and observation-al rating tool	Two surveys: *SafeTeamA & SafeTeamB*; 23 items total; 5-point Likert scale Psychometrics: Internal consistency: Cronbach's alpha (0.73-0.84)	EPOC: observational rating tool for non-technical skills: record frequency of explicit oral communication between professionals Psychometrics: Reliability: Intraclass coefficient >0.60	30-minute observa-tions	Informal interactions on unit	Staff nurses, nurse managers, physicians, residents

Kemper et al. (2016) also used multiple methods, a combination of surveys and an observational rating tool, to comprehensively examine teamwork in the ICU. The investigators conducted a pre-post study to examine the effects of a team training intervention on clinicians' development of team situational awareness. Prior to and following the intervention, ICU clinicians in the control and intervention group completed a combination of surveys, SafeTeamA survey and SafeTeamB survey. Together these surveys totaled 23 items and asked clinicians to report on their: 1.) attitudes toward team situational awareness and 2.) perceptions regarding *individual* and *team member* behaviors related to team situational awareness. The authors also hypothesized that teams reporting greater situational awareness would also demonstrate more

frequent use of verbal communication in practice since this behavior theoretically enhances team situational awareness. And so, Kemper et al. (2016) also trained observers to use an observational rating tool to collect data on the frequency and quality of explicit oral communication between team members. Observers collected data on clinicians in the control and intervention arm with the observational rating tool both prior to and following the team training intervention. Overall, the presented multi-methods studies propose that using complementary methods to assess IPC can yield a more complex understanding of IPC. Using multiple methods, or more rigorous mixed methods, does hold promise for examining IPC in practice; however, failure to identify an approach the measures the process of IPC among the described studies suggests a measurement gap still exists.

In summary, the literature presents various methods to assess interprofessional collaboration in the ICU to date. Qualitative methods are the most commonly used approach, with ten studies reportedly using a qualitative method to collect data on IPC in the ICU. Following qualitative methods, quantitative designs are also frequently reported with seven studies using survey methodology and three describing the application of an observational rating tool. Three studies identify using multiple methods to assess interprofessional collaboration in the ICU. Regarding measurement specifically, survey instruments are the most commonly used method; yet, the application of observational rating tools is becoming increasingly more common. There are marked limitations, however, to both of these measurement approaches. Survey instruments identified in the literature measure interprofessional collaboration as a fixed attribute of organizational culture, are specific to select clinician groups, and are prone to response bias. These surveys do not serve as a valid method to measure the uniquely complex process of IPC. Conversely, observational rating tools do provide a method to assess

interprofessional collaboration with increased objectivity by employing external observers to collect data on clinician behaviors as they engage in interprofessional collaboration and teamwork; yet, these tools focus exclusively on rating the quality of interprofessional interactions. Thus, the data collected using observational rating tools does not produce an objective quantification of the IPC process. Though the qualitative literature does not provide a mechanism to measure the process of IPC, it provides compelling evidence for the dynamic nature of IPC in ICU practice which suggests that a valid tool to measure the process of IPC should be sensitive to these changes. After appraising the measurement methods used to measure IPC, there is inconsistency between the conceptualization of IPC as a process and its current operationalization which reinforces the primary objective of the current project.

Outcomes of Interprofessional Collaboration in the ICU

Despite the described limitations for measuring interprofessional collaboration, prior studies aim to examine the relationship between interprofessional collaboration and outcomes in the ICU. These studies frequently use an implicit approach to examine the effects of interprofessional collaboration. That is, studies use the implementation of protocolized care practices like checklists, structured daily interprofessional rounds, unit-based multidisciplinary meetings, or re-engineered care teams responsible for performing specific functions like early mobility, as a proxy for IPC exposure (Dietz et al., 2014). Such protocolized care practices presumably standardize care and formalize interprofessional interactions; however, IPC is rarely explicitly measured. Though these studies do not explicitly measure interprofessional collaboration as a variable, they are included in the following section to demonstrate the state of the current science supporting the effects of IPC on ICU outcomes.

In previous iterations of the structure-process-outcome conceptual model, the outcome construct is often displayed as a single construct that focuses exclusively on patient outcomes. In the IPC framework, the outcomes construct is separated into three sub-constructs: system outcomes, clinician outcomes, and patient outcomes. This mirrors the sub-constructs presented in the structural factors but also signifies the scope of critical care outcomes that can be impacted by the process of interprofessional collaboration. For consistency, this review synthesizes and compares the literature around the effects of interprofessional collaboration on system, clinician, and patient outcomes in the intensive care setting, to date.

System Outcomes

System outcomes in the IPC framework include indicators of organizational performance such as service utilization or cost-effectiveness (Baggs & Schmitt, 1997; Lemieux-Charles & McGuire, 2006). Cost-savings is the most commonly reported system outcome in the ICU interprofessional collaboration literature. Implementing the following interprofessional practices are reported to reduce ICU care costs: a unit-based interprofessional care team to deliver early mobility (Corcoran et al. 2017; Lai et al. 2017; Morris et. al., 2008), an interprofessional weaning protocol (Henneman, Dracup, Ganz, Molayeme, & Cooper., 2001), institution of daily interprofessional rounds (Jain, Miller, Belt, King & Berwick, 2006) and pharmacy participation in interprofessional daily rounds (Leape et al., 1999; Saokaew, Maphanta, & Thangsomboon, 2009; Louzon, Jennings, Ali, & Kraisinger,2017). Though these studies report a decrease in costs, none were considered statistically significant. The unit of analysis was also not consistent across studies. To illustrate, outcomes reported include average costs saved in entire hospital stay (Lai et al., 2017; Morris et. al., 2008) vs. average cost saved per ICU stay (Henneman et al., 2001) vs. savings in pharmacy related expenses (i.e. ICU cost avoidance by preventing adverse

drug events) (Leape et al., 1999; Saokew et al., 2009). Heterogeneity in outcomes measures, in addition to the fact that the majority of these studies are single site quality improvement projects, limits the generalizability of the findings and prevents a conclusion for any relationship between IPC and cost-savings in the ICU.

In addition to reportedly decreased costs, improved resource utilization is also identified in the literature as an IPC system outcome. There are various approaches to operationalize resource utilization in the acute-care setting. Examples may include bed occupancy or use of specific services such as lab tests or specialty consults. In a retrospective cohort analysis, Rothen and colleagues (2007) aimed to identify those factors which predict the likelihood an ICU will be classified as a "most efficient ICU", characterized by low standardized mortality and standardized resource use (SRU). The investigators analyzed data from 275 ICUs to determine the "expected number of ICU days" required for likely survival in select ICU patient groups—stratified by severity of illness. The investigators categorized individual ICUs as low standard resource use if the reported average LOS was below the expected ICU LOS for the select patient groups and as high standard resource use if the average LOS exceeded the expected ICU LOS. When examining factors that predict likelihood of belonging to an efficient ICU, Rothen and colleagues found that implementing daily interprofessional rounds significantly increased the likelihood an ICU would belong to a "most efficient ICU" (n=16,560 patients, 275 ICUs; (aOR 2.7 95% CI 1.2–6.2). No other studies identified in the literature reproduce a similar effect of interprofessional collaboration on resource use in the ICU.

Overall, there is weak evidence supporting a relationship between interprofessional collaboration and system outcomes, such as resource utilization and cost-containment, in the ICU. The reason for this weak evidence is two-fold. First, there is heterogeneity in reported

system outcomes which suggests the current literature has yet to identify and study appropriate outcome measures to examine the hypothesized effects of IPC on system outcomes. Additionally, the current evidence is almost exclusively made up of observational studies and single site quality improvement studies which represent low and very low-quality evidence ("GRADE Working Group", 2004). Observational studies are criticized for having low internal validity due to failure to control for cofounding factors in study design (Melnyk & Morrison-Beedy, 2012). Single site quality improvement studies have low generalizability and are typically underpowered due to small sample size. Together these limitations make it difficult to estimate the effects of IPC on outcomes when using these study designs. And so, a combination of imprecise outcomes measures and weak study designs contribute to the current state of the science, where there is little evidence supporting a significant positive effect of IPC on system outcomes in the ICU. Applying more rigorous study designs and examining theoretically informed outcome measures in future work may address the current gap in the IPC literature.

Clinician Outcomes

Clinician outcomes include those outcomes related to clinician well-being and productivity. Similar to system outcomes, a consistent relationship between interprofessional collaboration and clinician outcomes is not found in the current literature. In studies examining the effects of interprofessional collaboration, clinician well-being is commonly operationalized as a psychosocial outcome. Interprofessional collaboration is hypothesized to be a protective factor against negative psychosocial outcomes such as anxiety or emotional exhaustion (also known as burnout). Karanikola, Papathanassoglou, Kalafati, & Stathopoulou, (2012) and Welp, Meier, & Manser (2016) similarly aimed to test this hypothesis by using a survey design to examine the effect of clinician perception of interprofessional collaboration on these respective

outcomes. The results from these studies, though not significant, trended in the hypothesized direction; when ICU clinicians report positive perceptions towards IPC in their workplace, they tend to report lower rates of anxiety and emotional exhaustion. Focusing on positive psychosocial benefits from IPC, in a pre-post-controlled study designed to examine the effect of a team training intervention on clinicians' development of team situation awareness, Kemper et al. (2016) reported as a secondary outcome the significant positive effect of team training on clinician self-reported emotional attachment to the ICU.

Regarding the effect of IPC on clinician productivity in the ICU, studies in the current literature operationalize this variable as both perceived appropriateness of care delivery and job satisfaction. Piers et al. (2011) reports in a cross-sectional analysis (N=1651 clinicians from 82 ICUs) that a positive perception of collaboration is associated with a lower odds of reporting perceived inappropriateness of care (OR, 0.72; 95% CI, 0.56-0.92; P = .009). Anstey, Adams, and McGlynn (2015) reported similar results in a smaller sample of ICU nurses and physicians working in over 50 ICUs across the state of California (n=1,169). The investigators found that reporting poor collaboration between nurses and physicians was associated with a higher odds of reporting perceived inappropriate care (OR 1.84, 95% CI 1.21 to 2.80). If clinicians perceive that the care they are providing is futile, this can undermine their work satisfaction and contribute to burnout (Costa & Moss, 2018). Concerning job satisfaction, positive nurse-physician collaboration has been found to be associated with perceived autonomy and work satisfaction among nurses (Georgiou, Papathanassoglo, & Pavlakis 2017). An increase in job satisfaction was also reported by Kemper and colleagues (2016) after the investigators implemented a team training intervention in the ICU.

Overall, the direct relationship between interprofessional collaboration and clinician outcomes is not frequently examined. This introduces a major gap in our current understanding of the effects of interprofessional collaboration in the ICU setting. As previously described, clinician interactions are the key mechanism underlying the process of IPC. Acknowledging this attribute of IPC, it seems reasonable to argue that examining the effects of IPC on clinician outcomes should not be overlooked. Understanding how the process of IPC directly impacts those clinicians engaged in the process may reveal insights into what motivates clinicians to participate in the process and how variation in the quality and quantity of IPC affects clinicians' willingness to participate in IPC. Further, it is well documented that there is a projected workforce shortage for critical care providers as the demand for critical care services continues to rise (Angus et al., 2000). This overwhelming demand places increased pressure on ICU clinicians. Additionally, evidence suggests that ICU clinicians are at higher risk for burnout which can result in decreased productivity, poor decision-making, and high turnover rates (Reader, Cuthbertson, & Decruyenaere, 2008). The reported observational data indicates interprofessional collaboration may be a protective factor against these poor clinician outcomes (Karanikola et al., 2012; Welp et al., 2016). However, this area of research warrants further attention seeing that overall there is a paucity of evidence for the effects of interprofessional collaboration on clinician outcomes in the ICU.

Patient Outcomes

Patient outcomes are defined as "values of recovery, restoration, and survival" (Donabedian, 2005). The effect of interprofessional collaboration on patient outcomes in the ICU is the most commonly reported outcome, compared to system and clinician outcomes.

Various approaches have been used to test the effect of interprofessional collaboration on patient outcomes. Observational studies report measuring the perception of collaboration among ICU nurses and physicians via surveys and testing its association with patient outcomes (Baggs et al., 1999; Huang et al., 2010, Boev & Xia, 2015; Manojlovich, Antonakos, & Ronis, 2009). Other approaches includes testing the effect of instituting daily interprofessional rounds on patient outcomes via multicenter cohort studies in which the outcomes of units that implement rounds are compared to units that do not, (Kim, Barnato, Angus, Fleisher, & Kahn, 2010; Yoo, Edwards, Dean & Dudley, 2016) and through retrospective single center studies in which unit outcomes are compared before and after the implementation of rounds (Stone et al., 2011; Narasimhan, Eisen, Mahoney, Acerra, & Rosen, 2006; Johnson et al., 2009). Moreover, other studies report evaluating patient outcomes after implementing interprofessional care protocols such as collaborative weaning protocols or unit-based interprofessional teams responsible for delivering complex interventions like early mobility to mechanically ventilated patients (Henneman et al., 2001; Barnes-Daly, Phillips, & Ely, 2017; Pun et al., 2018, Corcoran et al., 2017, Morris et al., 2008, Lai et al.,2017; Writing Group…Bricnet et al., 2016). Lastly, testing the effects of ICU clinicians participating in team training interventions on patients outcomes is another reported approach to examine the effect of IPC (Kemper et al., 2016).

The patient outcome measures vary across these different studies. Examples of ICU patient outcomes discussed in the IPC literature include: **mortality** (Kemper et al., 2016; Kim et al., 2010; Writing Group…Bricnet) et al., 2016; Yoo et al., 2016), **length of stay** (Corcoran et al., 2017; Henneman et al., 2001; Kemper et al., 2016; Morris et al., 2008; Narasimhan et al., 2006; Writing Group…Bricnet et al., 2016) **duration of mechanical ventilation** (Henneman et al., 2001; Lai et al., 2017; Morris et al., 2008; Writing Group…Bricnet et al., 2016) **rate of**

healthcare associated infections (HAIs) (Boev & Xia, 2015; Johnson et al., 2009; Stone et al., 2011; Writing Group…Bricnet et al., 2016; Manjlovich et al., 2009) **and readmission rates** (Corcoran et al., 2017; Kemper et al., 2016). Some studies do report a **significant relationship** between the respective interprofessional care practices and patient outcomes including **ICU LOS** (Henneman et al., 2001; Lai et al., 2017; Morris et al., 2008), **hospital LOS** (Corcoran et al., 2017; Morris et al., 2008), **mortality** (Baggs et al., 1999; Kim et al., 2010; Yoo et al., 2016; Pun et al., 2018), **duration of MV** (Pun et al., 2018; Corcoran et al., 2009), and **healthcare associated infections** including **central line associated bloodstream infections (CLABSI)** (Boev & Xia, 2015) and **ventilator-associated pneumonia (VAP)** (Boev & Xia, 2015; Johnson et al., 2009; Stone et al., 2011). However, a consistent relationship between IPC and patient outcomes is not identified. Additionally, this body of evidence is largely comprised of observational or single site quality improvement studies which represent lower quality evidence ("GRADE Working Group", 2004). Overall, though the effect on interprofessional collaboration on patient outcomes in the ICU is frequently reported, the strength of the evidence is poor, and the results are largely inconclusive.

A comprehensive review of the literature for the relationship between IPC and patient outcomes in the ICU also reveals that there is no evidence for the relationship between IPC and long-term patient outcomes. In more recent critical care outcomes research, there is a greater emphasis on examining long-term patient outcomes as the proportion of patients who survive critical illness continues to rise (Needham et al., 2012; Hill, Fowler, Pinto, Herridge, Cuthbertson, & Scales, 2016). Up to half of these patients will suffer from some degree of Post-intensive care syndrome (PICS), a condition characterized by a sequalae of cognitive decline, physical limitations, and psychological distress following a critical care encounter (Rawal,

Yadav, &, Kumar, 2017; Iwashyna, Ely, Smith, & Langa, 2010; Pandharipande et al., 2013). Optimizing care delivery in the ICU setting may prevent the onset of these poor outcomes (Davidson, Harvey, Bemis-Dougherty, Smith, & Hopkins, 2013). Since interprofessional collaboration is a crucial component of the delivery of effective and efficient intensive care services, IPC may also have the potential to affect long-term patient outcomes. Examining the relationship between IPC and long-term patient outcomes is thus recommended in future work.

In summary, there are significant gaps in interprofessional collaboration outcomes research in the ICU. First, and foremost, the quality of evidence for examining the effects of interprofessional collaboration is low; more rigorous study designs and statistical approaches are needed to adequately examine the relationship between interprofessional collaboration and system, clinician, and patient outcomes. Secondly, most studies examine the effects of interprofessional collaboration through the delivery of different care protocols such as daily rounds or using an interprofessional care team to deliver complex interventions like early mobility. These studies do not explicitly measure the collaborative process. Though collaboration may be inherently involved in the delivery of such protocols, it is difficult to determine if the reported system, clinician, and patient outcomes are the result of protocolized care or interprofessional collaboration. Furthermore, the current lack of strong evidence supporting the link between IPC and subsequent system, clinician, and patient outcomes in the ICU may be due to a high degree of heterogeneity in IPC exposure—a phenomenon that cannot be adequately tested if we assume an all or none dose of IPC is delivered when a protocolized care practice is used, opposed to measuring the process of IPC explicitly. Ultimately, with the current evidence, we cannot determine what ICU outcomes are directly affected by changes in IPC which indicates a threat to internal validity in this science.

Additionally, there is a paucity of evidence describing a relationship between IPC and system and clinician outcomes compared to patient outcomes. Conversely, in the larger pool of studies examining the effects of IPC on patient outcomes, the relationship between IPC and long-term patient outcomes is unexplored. Efforts to address these gaps in future work can be futile, however, if a valid and reliable method to measure the process of IPC is not identified. In sum, though the rhetoric for interprofessional collaboration having a positive impact on ICU outcomes is strongly accepted, there is not substantial evidence supporting this claim. One may argue that addressing the current measurement limitation is the logical next step to advance the science towards accurately identifying the effects of interprofessional collaboration on ICU outcomes.

Time-motion Methodology: An Approach to Quantify Care Processes

One potential way to address the current measurement limitations in the study of interprofessional collaboration in the ICU is the use of time-motion methods. Time-motion methodology is a validated approach historically used in industrial and operations engineering to measure and evaluate industrial processes (Lopetegui, et al., 2014). The general purpose of time-motion studies is to determine the average time it takes a qualified worker to complete a process under normal working conditions (Niebel, 1982). To fulfill this purpose, the process of interest is first broken down into a series of individual observable tasks. An external observer then collects data on the time it takes the average qualified worker to complete those individual tasks while using direct continuous observation (Shepherd & Stammers, 2005). By utilizing this approach, time-motion studies can identify inefficiencies in process completion. Essentially, through time-motion data analysis, one can detect patterns in process completion and recognize specific tasks that are frequently repeated or require extra time. When proposing methods to maximize

productivity, these specific tasks provide critical points to intervene to reduce waste in time, materials, or human effort (Lopetegui et al., 2014).

Before implementing a time-motion study, it is necessary to first develop a time-motion tool to collect the appropriate data. Time-motion tools comprise of multiple components. All time motion tools include a task list that is specific to the process of interest. The tasks on the list should be clear and observable so the observers applying the tool can collect valid and reliable data. Task lists are developed through an intricate understanding of the process which can be acquired by observing or interviewing workers who regularly engage in the process (Wetterneck et al., 2012). In addition to a task list, time-motion tools also include a timer with a start and stop feature to capture the duration of observed tasks. This can either be an explicit start and stop button or an embedded function in the tool so that when a task is selected from the list, a timer starts until a new task is selected. Data collected via time-motion tools is typically time-stamped to indicate the exact time each task occurred over the observation period. Time-motion tools can also include additional descriptive items such as other personnel who may be involved in the task, equipment involved in the task (depending on the process), as well as the location of each task (Pizziferri et al., 2005; Walter et al., 2014). Once the tool is finalized, trained observers can use the tool to collect the relevant time-motion data.

The uptake of time-motion methods in healthcare is increasingly more common. The health system is fraught with marked inefficiencies and excess waste that can compromise care quality and contribute to inordinate costs. There is a broad literature base of published time-motion studies conducted across diverse settings for diverse purposes in the healthcare system (Finkler et al., 1993; Tipping et al., 2010; Zheng et al., 2011). One of the most frequently reported uses of time-motion methods is to examine clinician and hospital workflow. For

example, multiple studies have used time-motion methods to examine how the institution of electronic health records and other forms of information technology, such as computerized provider order entry (CPOE), affect clinician workflow patterns (Carayon et al., 2015; Westbrook, Li, Georgiou, Paloni, & Cullen, 2013; Pizziferri et al., 2005; Poissant, Pereira, Tamblyn, & Kawasumi, 2005; Overhage, Perkins, Tierney, & McDonald, 2001).

Since time-motion studies have already been used in healthcare to quantify macro processes like workflow, it may also be a useful approach to quantify micro processes embedded in workflow like collaboration. Applying time-motion methods to quantify the process of interprofessional collaboration not only provides an opportunity to match the conceptualization of collaboration as a process with its operationalization, but time-motion data also can be used to generate a more in-depth understanding of the collaborative process. To illustrate, I discuss three applications of time-motion methods to quantify care processes in the ICU setting.

Ballermann and colleagues (2011) conducted a time-motion study in two Canadian ICUs to quantify differences in ICU clinician workflow. The investigators observed ICU physicians, nurses, respiratory therapists, and unit clerks. Trained observers used the Work Observation Method by Activity Timing (WOMBAT) tool to collect time-motion data on workflow. The task list included nine categories: direct patient care, indirect patient care, medication activities, documentation, professional communication, administrative tasks, in transit, supervision/education, social/personal activities, and paging. The WOMBAT tool was originally developed and applied while observing clinicians working in general acute care units and emergency rooms in Australia; the tool applied by Ballermann and colleagues included slight modifications to the task list which included specific examples related to ICU care under the same nine categories. By using the same time-motion tool applied in previous studies, the

investigators were able to explore differences in clinician workflow across different care settings. The investigators did not aim to determine if there were significant differences in time spent on tasks between ICU clinician roles, however the descriptive results suggest there is variation in task distribution. For example, it appears physicians spend up to 73% of their time in professional communication vs. about 22% in indirect patient care and closer to 5 % in direct patient care, compared to nurses who appear to spend 38% of their time in professional communication, 32% in indirect care and 30% in direct care, compared to RTs who spend 54% of their time in professional communication vs. 30% in indirect care and 16% in direct care. The roles and responsibilities of the respective roles are unique and so it stands to reason that time spent in different tasks would be variable. One could anticipate that differences could also be identified in how clinicians spend their time in tasks related to interprofessional collaboration since it is a process embedded in clinician workflow.

The timestamped data acquired via time-motion studies can also be used to identify patterns in process completion. Complex processes like workflow and collaboration do not necessarily adhere to a linear sequence of tasks and so the timestamped data can be used to determine if there are any relationships among tasks (i.e. if certain tasks, or pairs of tasks, consistently precede other tasks). Carayon and colleagues (2015) demonstrate this application in a study they conducted in three ICUs in the US within the same health system to examine if there were any distinct differences in physician workflow after the health system implemented a new electronic health record (EHR). The investigators conducted three months of observations both before and after the hospital implemented the EHR system. They observed both resident (77 observation over 217 hours) and attending (24 observations over 72 hours) physicians. Carayon and colleagues used a different time-motion tool than Ballermann et al. (2011); this task list

consisted of four broad categories: direct patient care, care coordination, indirect patient care, and non-patient care tasks. In addition to determining if there were differences in the percentage of time spent on different tasks before and after EHR implementation, the investigators also examined relationships between tasks, calculating the frequency at which each task preceded other specific tasks in the list. For example, two specific items from the task list include: (1) conversation with physician team and (2) clinical documentation and review (defined as reviewing patient chart or notes); using the time-stamped data, the investigators reported that prior to EHR implementation, conversation with physician team preceded clinical review and documentation 24% of the time for the resident observations. Following EHR implementation, conversation with physician team preceded clinical review and documentation 40% of the observation time (Carayon et al., 2015). The change in frequency implies a change in physician workflow after EHR implementation. Transferring this to the field of interprofessional collaboration, identifying relationships between different components of the collaborative process can inform our understanding of IPC in practice. Furthermore, identifying certain components, or clinician behaviors, that consistently precede collaborative encounters could focus future efforts to enhance the process of collaboration in practice.

Lastly, there is the potential to use time-motion data to determine how structural factors influence the nature of care processes in the ICU. Hefter and colleagues (2016) used time-motion methods to examine how unit strain affects physician workflow. The investigators observed attendings and residents in 5 ICUs at a single institution over a 7-month period. Workflow was quantified using a task list similar to the task list utilized by Ballermann and colleagues (2011) with nine categories: direct patient care, indirect patient care, documentation, review, professional communication, administrative tasks, in transit, education, and personal time. Strain

factors were operationalized using six factors: unit census, number of patients awaiting to be transferred into unit at start of observation, number of patients awaiting to be transferred out of unit at start of observation, total number of patients admitted on observation day, total number of patients discharged on observation day, and average patient acuity determined by average Sequential Organ Failure Assessment (SOFA) score for patients in the unit during the observations. Linear regression modeling was used to examine if strain factors affected time spent on tasks. The results indicate that one strain factor—average SOFA score—affected time spent in direct patient care, education, and documentation. Each increase in average SOFA score was associated with a 25% increase in time spent on patient care and education and a 34% decrease in time spent on documentation; the statistical significance did not hold for the relationship between average SOFA score and time spent on patient care and education when the model was adjusted for unit type. Similar methods can be applied in future studies to examine how different structural factors affect time spent in the process of interprofessional collaboration. Furthermore, future work could also examine how time spent in different collaborative activities affects outcomes.

In summary, there is evidence that conducting time-motion studies in the intensive care setting is feasible, but its application to interprofessional collaboration is not yet known. Since interprofessional collaboration is defined as a process, it is reasonable to hypothesize that time-motion methods may also be an appropriate approach to quantify IPC. Additionally, if found to be a feasible approach, there are unique opportunities that can stem from time-motion data. Examples include finding differences in time spent on collaboration between different ICU providers and settings as well as identifying unique patterns in the use of collaboration in practice. Additionally, future work can examine how the distribution of time spent in

collaboration can affect pertinent clinical outcomes. Together this validates the purpose of the current study which aims to test the feasibility of using time-motion methods to measure the process of IPC in the ICU.

Gaps in the Literature

From the summarized literature, four fundamental gaps in the science surrounding IPC in the ICU exist. Specifically, the gaps include:

1. The failure to identify an approach to operationalize interprofessional collaboration as a dynamic process. Inconsistency between the conceptualization and measurement of IPC limits our understanding of interprofessional collaboration and its role in complex care delivery.

2. Time-motion methodology is a validated approach that can be used to evaluate processes. Previous studies indicate time-motion methods can be applied in healthcare to quantify care processes. Time-motion methodology has yet to be tested as an approach to quantify the process of interprofessional collaboration.

3. Interprofessional collaboration is theorized to improve the quality and safety of ICU care, but a consistent relationship between IPC and improved outcomes is not identified.

4. We lack a comprehensive understanding of system, clinician, and patient factors that facilitate or inhibit the process of interprofessional collaboration in practice.

This project aimed to directly address gaps 1 and 2 by testing the feasibility of using time-motion methodology to measure the process of interprofessional collaboration in the ICU. By addressing the measurement gap, we will be able to examine the relationships described in gaps 3 and 4 in future work.

Summary

In summary, this chapter critically appraises the literature surrounding interprofessional collaboration in the ICU. Interprofessional collaboration is a process composed of episodic interpersonal interactions during which professionals integrate their professional skills and knowledge to make a clinical decision or attain a patient centered goal. The conceptualization of IPC as a dynamic process does not match its operationalization in the current literature. Furthermore, despite efforts to "improve" interprofessional collaboration, there is limited strong evidence supporting the effects of structural factors on IPC and subsequently the effects of IPC on pertinent critical care outcomes. This project aimed to align the conceptualization of IPC as a process with its operationalization by testing the feasibility of using time-motion methods to quantify the process of IPC. Addressing the current measurement gap will lay the foundation for future work to rigorously test the relationships between structural factors, IPC, and outcomes.

Chapter 3: Methods & Design

The purpose of the current study was to test the feasibility of using time-motion methods to measure the process of interprofessional collaboration in the care of mechanically ventilated patients. To achieve this objective, I first created a task list for the process of IPC in the care of mechanically ventilated patients (Aim 1); I then tested the application of time-motion methods to measure the process of IPC in the care of mechanically ventilated patients (Aim 2).

To date, there is no prior evidence supporting the use of time-motion methods to quantify the process of interprofessional collaboration. This study examined interprofessional collaboration in the care of mechanically ventilated patients as a test-case to determine the feasibility of applying this method. The reason for focusing on the care of mechanically ventilated patients is two-fold. First, caring for mechanically ventilated patients is inherently interprofessional (Costa et al., 2018). The patient's bedside nurse, respiratory therapist, and physician are responsible for delivering liberation-driven care practices to ultimately achieve extubation. More specifically, the nurse manages the patient's pain and sedation and assesses the patient's readiness to wean, the respiratory therapist manages the ventilator settings and initiates the spontaneous breathing trial, and the physician integrates information and coordinates the decision to extubate (Blackwood et al., 2014). Secondly, mechanical ventilation is one of the most commonly delivered interventions in the ICU with 40% of ICU patients requiring mechanical ventilation, on average (Wunsch et al., 2013). Thus, by focusing on this care practice, I theorized that we would be able to frequently observe collaboration between the nurse,

respiratory therapist and physician. This chapters describes the methodology and analytical approach applied for each aim in the current study.

Human Subjects

The study protocol entitled 'Measuring the Process of Interprofessional Collaboration in the Care of Critically Ill Adults' was approved by the University of Michigan Institutional Review Board (HUM00147517). The study posed no more than minimal risk to participating clinicians. Verbal consent was received from individual clinicians prior to data collection and participants were compensated with a token of appreciation for their time.

Aim 1

Aim 1: Develop a task list for the process of interprofessional collaboration in the care of mechanically ventilated patients.

To create the final task list for the process of IPC, I analyzed two data sources: (1) a subset of previously collected qualitative data used to develop the task list and (2) a collection of interview data from three ICU clinicians who reviewed the developed task list.

Setting

The qualitative data was acquired from two medical ICUs (MICU) located in Southeastern Michigan. The first site is a 20-bed MICU located at a large urban academic hospital. The second site is a 20-bed MICU located at a community hospital.

Sample

Qualitative data was collected from 27 ICU clinicians (RNs, RTs, and MDs) who care for mechanically ventilated patients. The total reported sample size includes the clinicians who

completed shadowing and interviews in the parent study and the clinicians who participated in interviews to assess the validity of the developed task list.

Sources of Qualitative Data

Parent Study

The parent study applied an ethnographic approach of observations, shadowing and interviews to understand how the ICU team works together in the care of critically ill patients in two medical ICUs in Southeastern Michigan. Observation and shadowing data were collected using unstructured field notes. Interviews were conducted in-person or virtually and were audio-recorded and transcribed; each interview lasted approximately 60 minutes. In the interviews, clinicians were prompted to describe teamwork in the context of certain patient populations including mechanically ventilated patients, chronically ill patients and decompensating patients. Clinicians were also encouraged to provide narratives describing specific experiences where teamwork worked well, or not well, within these contexts. A sample of the interview guide for the parent study is included in the *Appendix*. In the parent study, participants received $40 incentive payments for participating in shadowing experiences and $20 incentive payments for participation in one-on-one semi-structured interviews. Participation was voluntary.

A subset of the qualitative data gathered in the parent study was analyzed in the current study; the details are described in the table below. As presented, I included all observation data from the parent data but limited the shadowing and interview data to items collected from RNs, RTs, and MDs only. By reducing the data, I was able to gather a more focused understanding on how RNs, RTs, and MDs specifically use interprofessional collaboration in the care of mechanically ventilated patients. Data from the parent study was analyzed to identify specific behaviors clinicians demonstrate when they are either attempting to initiate or are directly

engaging in a collaborative encounter with a clinician outside their profession. These behaviors could be verbal, such as communication, or nonverbal, like purposefully positioning oneself in a certain location. A detailed discussion on the analytic approach used to develop the preliminary task list from the parent study data is provided in the following section.

Table 6

Summary of Qualitative Data from Parent Study

Qualitative Approach	**Research Question**	**Total Hours/# of observations**	**Sample**		**Time of day**	**Description of data collectors**
Observations	What do teamwork and clinician interactions look like, generally?	31 hours/12 observations across site 1 and site 2 (14 hours/5 observations, Site 1; 17 hours/ 7 observations, Site 2)	Not applicable.		Weekdays and weekends between 0700-1630	2 observers per observation, 6 observers total (1 PhD RN, 1 Nursing Doctoral student, 1 Public Health doctoral student, 1 undergraduate nursing student, 2 non-clinician RAs)
Shadowing	What does teamwork look like more specifically with detailed context from a handful of clinicians?	43 hours/ 12 shadowing across site 1 and site 2 (21 hours/ 6 shadowing, Site 1; 22 hours/6 shadowing, Site 2)	RN	5 (3 Female, 2 Male)	Weekdays between 0600-2300	1 observer per shadowing (1 PhD RN, 1 Nursing Doctoral student, 2 non-clinician RAs)
			RT	4 (2F, 2M)		
			MD	3 (2F,1 M)		
Interviews	What do clinicians think about how their team works?	12 interviews across site 1 and site 2 (7 interviews, Site 1; 5 interviews, Site 2)	RN	5 (4 F, 1 M)		1 interviewer (1 PhD RN); interviews lasted approximately 60 minutes
			RT	3 (2 F, 1 M)		
			MD	4 (3 F, 1 M)		

Member-checking Clinician Interviews

Upon completion of the preliminary task list developed from the parent study data, I conducted separate member-checking interviews with representatives from each clinician role (i.e. RN, RT, and MD) to assess the validity of the preliminary task list (Birt, Scott, Cavers, Campbell, & Walter, 2016; Doyle, 2007; Torrance, 2012). Member-checking interviews are a formal mechanism by which analyzed data are presented to those who participated in the data collection, in this instance ICU clinicians, to gather insights from the respective participants on the veracity of the reported findings (Doyle, 2007). All clinicians who participated in the interviews were recruited from site 1 which also served as the site for the time-motion data collection (Aim 2). In the individual interviews, clinicians were asked to review and describe if the behaviors on the task list resonated with their clinical practice. Clinicians were also encouraged to provide explanatory examples when possible to further understand how he/she engages, or other clinicians engage, in certain behaviors. Lastly, clinicians were asked to identify any behaviors they perceived as unclear or missing from the current version of the task list. The interviews were conducted in-person and were audio recorded and then transcribed by an external transcriptionist. Each interview lasted approximately 30 minutes and participants received an incentive payment of $20. (See *Appendix* for member-checking interview guide).

Data Analysis

I analyzed the qualitative data using an iterative approach, applying both a directed content analysis and a conventional content analysis to develop the preliminary task list (Hsieh & Shannon, 2005). The purpose of these analyses was to identify specific clinician behaviors that indicate involvement in the process of interprofessional collaboration in the care of mechanically ventilated patients. I categorized the identified behaviors into collaborative activities and

enablers to collaborative activities and theorized that together these behaviors make up the collective process of interprofessional collaboration. Collaborative activities are defined as *clinician behaviors that indicate direct engagement in the process of IPC*. Enablers to collaborative activities are defined as t*he ways clinicians transition into or facilitate collaborative activities*. The decision to use the terms "enabler" and "collaborative activity" was chosen *a priori;* the selected terms are intended to capture the unique antecedents to and attributes of interprofessional collaboration which represent different components of the greater IPC process (Henneman et al., 1995; Xyrichis & Ream, 2008).

To develop the preliminary task list, I first analyzed the site 1 observation, shadowing, and interview data by coding specific instances in which clinicians were observed or described interacting with clinicians outside their profession. I collectively grouped these interactions as collaborative activities. I also identified specific clinician behaviors that were observed or described as occurring before the identified collaborative interactions and coded these behaviors as enablers to collaborative activities. I reviewed the extracted data with a second reviewer who is an expert in ICU team dynamics and participated in the data collection. We used an inductive approach to propose distinct types of collaborative activities and enablers to collaborative activities that emerged from the subset of data (Hsieh &Shannon, 2005). From this analysis, we generated a list of behaviors which included seven distinct collaborative activities and ten distinct enablers to collaborative activities. I then created a comprehensive "codebook" to serve as the framework for subsequent qualitative analyses. The codebook included: a.) the list of collaborative activities and enablers, b.) a definition describing each collaborative activity and enabler, c.) specific examples from the site 1 data that demonstrate each collaborative activity and enabler, and d.) a list of exclusion behaviors for certain collaborative activities and enablers

to increase clarity. I reviewed the codebook with a third reviewer who is an expert in qualitative methods to determine if the codebook was clear, coherent and sufficiently grounded in the data to a naïve reader (i.e. not a content expertise and did not participate in data collection). After completing the first version of the codebook, I created the preliminary task list for the process of interprofessional collaboration which included the list of collaborative activities and enablers along with each behavior's definition.

As described in the description of qualitative data sources, I then conducted three member-checking interviews with ICU clinicians to assess the validity of the preliminary task list. I applied a content analysis to the transcribed interview data (Graneheim & Lundman, 2004). I coded confirmatory examples—classified as specific examples provided by the clinicians that were consistent with the provided definitions—in the individual interviews. I also summarized any recommended changes from the individual clinicians. I reviewed the interview data and analysis with a second reviewer and together we used negotiated consensus (Bradley, Curry, & Devers, 2007) to determine the most appropriate changes to make to the preliminary task list.

After the member-checking interviews, I revised the codebook to include an additional collaborative activity. I then partnered with a qualitative analyst to horizontally code (i.e. apply codes from the codebook across all sources of data) the site 1 and site 2 data with the finalized codebook. Both the qualitative analyst and I coded all of the observation, shadowing, and interview data from site 1 and site 2. The purpose of this additional analysis was to: a.) explore how the specific collaborative activities and enablers to collaborative activities were distributed over the different data sources (i.e. observation, shadowing and interview data) b.) evaluate the applicability of the IPC task list in a separate ICU setting (i.e. site 2) and c.) increase the reliability of the results by having multiple coders. This analysis culminated in the creation of the

final task list for the process of interprofessional collaboration which is presented in the results section.

The final task list was then incorporated into the time-motion tool used to collect data on interprofessional collaboration in the care of mechanically ventilated patients (Aim 2). A detailed description of the tool development is described in the following section.

Tool Development

Two versions of the time-motion tool were created: a paper form and a mobile application for iOS operating systems. Both versions contained the same components; the application was developed to streamline data collection and analysis. I partnered with the Center for Healthcare Engineering and Patient Safety at the University of Michigan to develop the mobile application. An interdisciplinary team of students and professionals (nursing doctoral student, undergraduate pre-med student, undergraduate computer science student, and a masters-prepared industrial/operations engineer with a concentration in healthcare engineering and patient safety) worked together to complete the project. I presented the team with an inventory of items to include in the tool and together we negotiated the best organization and layout for the application. Once the front-end of the application was finalized, we consulted with an MD/PhD student with previous experience in application development to construct the data storage. The computer science student independently built the application using Xcode software. The final application was installed on two iOS tablet devices. Application development through implementation was completed in three months.

We designed the final application to include two parts: 1.) an initial screen which opened after launching the application and prompted the user to enter his/her initials and select the

clinician role they were preparing to observe and 2.) the actual time-motion tool. We designed the tool interface as a split screen; both the left and right side of the screen were mirror images of the following items (See screen shot of tool in *Appendix*):

1.) A timer (counts in seconds)

2.) Start and stop button

3.) A column of individual enablers from the final task list

4.) A column of individual collaborative activities from the final task

5.) Clinician role (with pre-populated options)

6.) Location (with pre-populated options)

7.) Save button to upload individual entries to data file

8.) "Trash" button to delete any entries

I included the additional descriptive items, clinician role and location, to be consistent with other time-motion tools applied in the healthcare setting that describe including similar items (Pizziferri et al., 2005; Walter et al., 2014). Furthermore, understanding the clinician roles frequently involved in the IPC process as well as the location of such interactions can have implications for future practice interventions and so these items were also included to support a more comprehensive evaluation of the IPC process. The save function was disabled until all items were selected; once an entry was saved, it was automatically timestamped.

Observer Training

After finalizing the tool, the next step was to train the observers who would be participating in the time-motion data collection to accurately and reliably use the tool. I trained two observers, in addition to myself, to use the tool and participate in the data collection. Both

observers were previously trained to collect survey data in the ICU and had experience interacting with ICU nurses, respiratory therapists, and physicians. The training for the time-motion tool included a didactic component designed to introduce the observers to the tool and its intended application in the ICU environment, and an application component during which the observers could practice independently using the tool. The application component of training was also used to evaluate reliability among the observers using the tool.

Didactic Training

The observers were first asked to independently review material describing the general ICU environment. The information provided in this training was intended to increase the observers' familiarity with the ICU patient population and the different provider roles they would interact with while conducting observations in the clinical setting. Specifically, the material outlined common medical diagnoses and interventions delivered to critically ill patients, the roles and responsibilities of different healthcare professionals involved in the care of critically ill patients, and information on mechanical ventilation—highlighting common terminology and the application of ventilator weaning protocols. The information was provided to the observers in a voiceover PowerPoint presentation and was prepared by the project lead (EMB, a registered nurse) in collaboration with an experienced critical care nurse and nurse researcher.

The next portion of the didactic training was intended to increase observers' conceptual understanding of the items on the time-motion tool and its application in the clinical setting (Castorr et al., 1990; Ballermann et al., 2011; Eppich et al., 2015; Haidet, Tate, Divrilio-Thomas, Kolanowshi, & Happ 2009; Pecanac, Rainbow, Doherty-King, & Steege, 2018). Observers independently reviewed material describing the time-motion approach, the different components

of the time-motion tool including the definitions for the individual enablers and collaborative activities, and the data collection protocol. This information was similarly presented to the observers in a separate voiceover PowerPoint presentation that was developed by the project lead (EMB). After completing the didactic training, the observers advanced to the application phase.

Video Training

The observers practiced applying the time-motion tool while viewing video recordings. In each video, specific collaborative activities and enablers to collaborative activities from the final task list were simulated. The extant literature describes video training as an acceptable approach to prepare data collectors to reliably use observational tools (Slagle, Weinger, Dinh, Brumer, & Williams, 2002; Haidet et al., 2009; Dempsey, Iwata, Fritz, & Rolider, 2012; Russ et al., 2012; Eppich et al., 2015; Yule et al., 2008). The benefits of using video recordings include standardization of training across multiple raters and reduced duration of overall time spent in training (Dempsey et al., 2012; Pecanac et al., 2018).

Implementing a similar approach, I developed 10 video scenarios to demonstrate enablers and collaborative activities from the developed task list. I partnered with two undergraduate students in the Department of Film, Television, and Media at the University of Michigan to create the videos. One student was appointed as the lead videographer and the other served as an assistant. All of the videos were recorded in the University of Michigan School of Nursing Simulation Lab which included a fully equipped ICU room. The length of each video ranged from 30 seconds to two minutes.

I developed the scripts for each scenario by using examples coded in the qualitative data. During the qualitative analysis we found that enablers and collaborative activities sometimes

occurred in immediate succession or, conversely, an enabler or CA happened intermittently. To demonstrate this variability, a portion of the videos included multiple items (enablers and CA) from the task list and the remaining included one enabler or one collaborative activity. The clinician role demonstrating the different collaborative activities and enablers from the task list also varied across video scenarios. This was intended to prepare the observers to use the time-motion tool to collect data from the different clinician roles (i.e. physician, respiratory therapist, and nurse) in practice. We also varied the location where the behaviors took place (i.e. patient room, hallway, and nursing station).

I watched the final videos and created the evaluation criteria by recording the appropriate identification and estimated duration of each IPC behavior for each video. Three sets of criteria were created for each role: nurses, physicians, and respiratory therapists. Some of the videos were used more than once to capture behaviors demonstrated by different clinician roles in the video. In total, data was collected on 16 scenarios across the 10 videos. A table describing each video scenario in detail is provided in the *Appendix*.

The observers completed two iterations of the video training, with a month-time lapsed in between viewing the videos. I was interested in first evaluating if the RAs could identify a behavior as a collaborative activity or enabler, broadly, and then if they could differentiate the specific type of collaborative activity or enabler (i.e. differentiating information exchange, a collaborative activity, from providing help, another collaborative activity, for example). During the first iteration, the two RAs viewed the material independently and then completed the video training using the paper version of the tool. After the first iteration, the RAs achieved moderate agreement in identifying clinicians' behaviors as collaborative activities or enablers broadly (**63% for RA 1 and 42% for RA 2**), but the agreement for the specific types of collaborative

activities or enablers was poor (**below 40% for both RA 1 and RA 2**)**.** In review of the procedure, RA 2 interpreted the directions as recording how the clinician roles "receive" collaborative activities and enablers versus how the roles initiate the enabler or collaborative activity which likely contributed to low reliability.

Based on this preliminary analysis, I coordinated a second iteration of training where the two RAs and myself met in-person. We reviewed the definitions of the collaborative activities and enablers and described different examples, emphasizing those behaviors we consistently identified differently. Afterward, I had the two RAs complete the video training again using the application version of the tool. Following the second iteration of the training, the percent agreement for identifying clinicians' behaviors as collaborative activities or enablers was close to the 80% goal (**83% for RA 1 and 78% for RA 2**) (Haidet et al., 2009). The percent agreement for identifying appropriate type was lower (**66% for both RA 1 and RA 2**). I also calculated two kappa statistics for each RA for (1) identifying behaviors as enablers or collaborative activities broadly and (2) for identifying specific types of enablers and collaborative activities (see Table 7 and 8). All kappa statistics were greater than 0.60 which indicates substantial agreement (Landis & Koch, 1977). A separate analysis was conducted to determine if each observer could reliably capture the duration of the IPC behaviors since time is a continuous variable (Lopetegui et al., 2013). I used the ICC test to determine if the RAs and I could reliably time the duration of clinician behaviors. To do so, I first summed the total time recorded per video scenario and then compared the total times per scenario to determine the reliability across all three raters. The individual ICC and average ICC measure were 0.80 and 0.92 which indicates good and excellent reliability, respectively (Portney & Watkins, 2000).

Table 7
Kappa Coefficients for Identifying IPC Behavior as Enabler or CA

Rater	N	% Agreement	Expected Agreement	Kappa	Std. Error
1	29	82.76%	44.71%	0.69	0.16
2	32	78.13%	42.77%	0.62	0.15

Table 8
Kappa Coefficients for Identifying Specific Types of IPC Behaviors

Rater	N	% Agreement	Expected Agreement	Kappa	Std. Error
1	29	65.52%	8.56%	0.62	0.05
2	32	65.63%	7.42%	0.63	0.05

Table 9
ICCs for Total Duration of IPC Behaviors per Video

N	ICC Single (95 %CI)	ICC Average (95% CI)
16	0.80 (0.61-0.92)	0.92 (0.83-0.97)

Prior to conducting observations on the unit, I met with each RA one-on-one to discuss the specific instances/videos in which we identified specific behaviors differently to prepare for data collection in the clinical setting. We then reviewed the standardized procedure for conducting the observations on the unit, the informed consent process and the incentive payment process.

Aim 2

Aim 2: Determine the feasibility of using time-motion methodology to measure the process of interprofessional collaboration in the care of mechanically ventilated patients.

Setting

We collected time-motion data while observing ICU clinicians delivering care to mechanically ventilated patients in a single 20-bed medical ICU located at a large urban academic hospital in Southeastern Michigan (site 1 in Aim 1). This ICU has an average of 10 mechanically ventilated patients per week.

Sample

We collected time-motion data from18 ICU clinicians (RNs, RTs, and MDs) who cared for mechanically ventilated patients. All clinicians who participated in the observations were compensated with a $40-dollar gift card.

Inclusion/Exclusion

All ICU clinicians (nurses, respiratory therapists, physicians) who were 18 years or older, currently licensed in their respective professions, permanently employed by the study hospital and responsible for providing direct patient care in the site ICU at the time of the study were eligible to participate. Clinicians were excluded from this study if they did not meet the inclusion criteria, were not caring for at least one mechanically ventilated patient during the shift in which the data was being collected, declined to participate, had previously participated in an observation for this study, or verbally expressed discomfort about the observation.

Data collection

Pilot week

Prior to collecting the primary data, I conducted one week of pilot observations. The purpose of the pilot observations was to introduce the study to the clinical staff and to test the proposed data collection approach. I completed three days of data collection with each

observation period lasting approximately four hours. For the pilot week, the paper version of the time-motion tool was used. After the pilot week, I slightly modified the data collection approach. I originally proposed to have observers enter patient rooms to collect the data, however while completing the pilot observations, many of the patients were on contact precautions which requires personnel entering the room to wear protective equipment. To reduce interference with the data collection approach as well as risk for spreading infection, I requested that observers not enter the patient's room in future observations. Observers were still able to observe IPC behaviors in the patient room while standing at the door of the patient's room.

Primary data collection

After the pilot observations, we completed 18 days of primary data collection over a nine-week period. We limited our data collection attempts to three days a week to minimize burden on clinical staff; we averaged about two days of data collection per week. On each day of data collection, one observer was paired with one clinician. Before starting the data collection, the observer reviewed the informed consent document and then received verbal consent from the participant. The clinician was also asked to fill out a demographics survey specifying his/her age, race, gender, years of experience, and years working in the site ICU. Following completion of the demographics survey, the observer began collecting the time-motion data. All primary data was collected using the application version of the time-motion tool.

The general purpose of time-motion studies is to determine the average time it takes a qualified worker to complete a process under normal working conditions (Niebel,1982). In this study, we aimed to quantify the average amount of time each professional role engages in the process of interprofessional collaboration while caring for mechanically ventilated patients in routine clinical practice. To achieve this outcome, we strived to observe each professional role

over the same time frame. For each professional role, we completed six days of data collection while observing a different individual on each day. Data was collected on both the weekdays and weekends to minimize selection bias (Richardson et al., 2016; Ballermann et al., 2011). We tried to rotate the role observed by week to maximize variation in sampling. Over the nine-weeks, we conducted two weeks of consecutive physician observations to accommodate their service schedule. A figure presenting the data collection schedule is displayed below.

Figure 2

Data Collection Schedule

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Week 1						RT	
Week 2		MD			MD		
Week 3			MD			MD	
Week 4		RT		RT			
Week 5			RN		RN		RN
Week 6			RT				
Week 7				MD			MD
Week 8		RN		RN		RN	
Week 9	RT				RT		

We were able to achieve adequate sampling variation for the RNs and MDs within the scheduled data collection attempts (i.e. 12 different individual clinicians observed across 12 days of data collection attempts). The RTs required 13 days of data collection attempts to achieve adequate sampling variation (i.e. six different individuals). The RTs used a unique "core scheduling" approach to staff the unit which resulted in a smaller sample size to select from among the RT staff. As seen in the figure above, there were weeks in which only one RT was observed; this was due to the described scheduling limitations. Each observation across the

different roles lasted approximately 3 hours and 20 minutes. Observers collected data in the morning between 0700 and 1230; the nurse and respiratory therapy observations were completed between 0700 and 1100 whereas the physician observations were completed between 0830 and 1230. This decision was based on feedback from the physicians that this time frame worked best for their workflow. The decision to conduct the observations during the morning portion of the day shift was based on evidence from the site 1 qualitative data in which representatives from medicine, nursing, and respiratory therapy similarly reported that collaborative practices around mechanical ventilation management typically occurred early in the morning in concurrence with rounds.

Post data collection

Following each observation, the observer uploaded the time-motion data for the day. In addition, the observer also filled out a post-data collection survey. The observer was first asked to answer the following questions: 1.) how many mechanically ventilated patients did the clinician care for during the observation period? and 2.) how many of these mechanically ventilated patients were extubated during the observation? Due to the nature of their professional roles and responsibilities, physicians and respiratory therapists are often involved in the care of multiple mechanically ventilated patients per shift compared to nurses who often care for only one mechanically ventilated patient per shift. We collected data on the count of mechanically ventilated patients to contextualize the results, assuming that by caring for more than one mechanically ventilated patient, some clinicians may exhibit a greater frequency of collaborative activities and enablers to collaborative activities. Furthermore, extubating a patient requires close coordination between the nurse, respiratory therapist and physician and would also theoretically increase the occurrence of collaboration between the respective clinicians. We could not predict

if all clinicians observed would participate in an extubation in each observation, so we collected this additional data to also contextualize the results. After answering these two questions, the observer was also asked to provide a free text response reflecting on the data collection process. The observer was prompted to describe any positives or negatives they experienced while collecting data on that observation day. This data was used to inform the feasibility of the data collection process.

Data Analysis

Descriptive Analysis of Time-motion Data

I used descriptive statistics to summarize the clinicians' demographic information and the observation data. Median and interquartile ranges were used to describe clinician age, number of years working in the site ICU, as well as the number of mechanically ventilated patients cared for by clinicians per observation period. Means and standard deviations are presented to describe the average length of time for the observations (in hours) by clinician role and by observer (Hefter et al., 2016).

I aggregated the data collected from the individual observations into a single dataset. I used descriptive statistics to analyze the frequency and duration of IPC behaviors in the care of mechanically ventilated patients. To determine the distribution of IPC behaviors across all the observations, I calculated the relative frequency of each collaborative activity and enabler to collaborative activities using the aggregated data. I then used cross-tabulation to determine the relative frequencies of collaborative activities and enablers to collaborative activities by clinician role. To describe the duration of IPC behaviors, I first calculated the mean length of time (in seconds) for each collaborative activity and enabler to collaborative activities across all the observations and by clinician role (Westbrook et al., 2011). To determine the proportion of IPC

time each collaborative activity and enabler behavior utilized, I summed the total time spent in IPC and the total time spent in each behavior across all the observations. I then calculated the proportion of IPC time spent in each collaborative activity and enabler to collaborative activities by dividing the total time spent in each behavior by the total time spent in IPC. An additional analysis was conducted using the same approach to determine the proportion of IPC time spent in each IPC behavior by clinician role. Bar graphs were created to display the respective results which is consistent with prior time-motion studies (Westbrook et al., 2011; Ballermann et al., 2011; Carayon et al., 2015; Hefter et al., 2016).

I completed additional descriptive analyses to describe what clinician roles were frequently engaged in the IPC process and to summarize the location of IPC interactions in the unit. I used cross-tabulations to determine the frequencies at which individual clinician roles were engaged in the IPC process by the clinician roles being observed (Westbrook et al., 2011). Options for individual clinician roles include nurse, respiratory therapist, Pulmonary/Critical Care Fellow, Attending, Resident, Intern and Other which included allied health providers such as pharmacy, social work and physical therapy. In the analysis, residents and interns were aggregated into one category to represent junior-level physicians. I also calculated how frequently we observed the IPC process between the three clinician roles we were observing. I classified this as the RN, RT, Fellow triad and it includes the instances where the nurse engaged in an IPC interaction with both the RT and Fellow MD or the RT engaged in an IPC interaction with both the RN and Fellow MD or the Fellow MD engaged in an IPC interaction with both the RN and RT. The remaining IPC interactions that did not fall into the respective categories were grouped into another category, more than one clinician role involved, and can include a combination of more than one distinct clinician roles. The location of IPC interactions included

five categories: patient room, hallway, nursing station, break room and other. I calculated the relative frequency of each location across all the observations using the aggregated data. Stata version 15 was used for all analyses.

Feasibility

To understand the dispersion of collaborative activities and enablers to collaborative activities over the observation days, I also calculated the proportion of observation days each collaborative activity and enabler was observed at least once. This information is displayed as a count for number of days observed and a percentage, out of 18 days, in the following Results section. Previous work evaluating observational rating tool development and application suggests that behaviors observed in less than 50% of cases, which I classify as individual observation days, may indicate low observability (Thomas, Sexton, & Helmreich, 2004; Hull, Arora, Kassab, Kneebone, & Sevdalis, 2011; Flowerdew at el., 2012).

I used conventional content analysis (Hsieh & Shannon, 2005) to examine the text data provided by the observers while reflecting on the data collection process. I identified broad themes and classified each as a strength or challenge which is recommended when evaluating the feasibility of data collection procedures (Scott, Albreacht, Given, Arseneau, & Klassen, 2016; Lavoie et al., 2018). In the results, I use examples from the text to describe each strength and challenge. I then propose changes to implement in future applications of the time-motion tool and data collection approach based on these findings.

Summary

In summary, this project used a combination of methods and analyses to complete the project's overall aim of testing the feasibility of using time-motion methods to measure the

process of IPC in the care of mechanically ventilated patients. I developed a task list for the process of IPC by analyzing a collection of observation, shadowing and interview data describing teamwork in two ICUs in the state of Michigan. Specific clinician behaviors demonstrating engagement in collaboration or used to facilitate a collaborative encounter were identified and labeled as collaborative activities or enablers to collaborative activities, respectively. The developed task list was reviewed and validated by three practicing ICU clinicians. After the task list was finalized, I developed a time-motion tool accessible via an iOS application in collaboration with the Center for Healthcare Engineering and Patient Safety at the University of Michigan. The tool included the final task list in addition to other descriptive items. Using simulation videos that I created, I trained two observers to use the time-motion tool and achieved adequate reliability among observers in using the tool. I, along with the two trained observers, used the tool to collect time-motion data on the process of IPC in the care of mechanically ventilated patients while observing 18 ICU clinicians working in a single ICU in the state of Michigan. Descriptive analyses were conducted to describe patterns in the IPC process and to inform the feasibility of the data collection approach.

Chapter 4: Results

The following chapter describes the results of the current study which aimed to test the feasibility of using time-motion methods to measure the process of interprofessional collaboration in the care of mechanically ventilated patients. First, I present the results of the qualitative analyses which were used to develop the task list for the process of interprofessional collaboration in the care of mechanically ventilated patients (Aim 1). I then present the results from the time-motion study in which we collected observational data on how different clinician roles participate in the IPC behaviors specified on the task list while caring for mechanically ventilated patients in practice (Aim 2). Descriptions of the clinician sample and observation sessions are presented followed by data displaying the frequency and duration of the respective IPC behaviors. Data informing the feasibility of the data collection process are also discussed.

Aim 1

Qualitative Results: Task List for the Process of Interprofessional Collaboration in the Care of Mechanically Ventilated Patients

The final task list includes ten enablers to collaborative activities (Table 10) and eight collaborative activities (Table 11). An additional collaborative activity, socializing, was added to the preliminary task list after receiving feedback from practicing ICU clinicians in the member-checking interviews that it is an important component of the collaborative process. In the following tables, I present the unique enablers to collaborative activities and collaborative activities, the associated definitions for each behavior, and examples from the observation,

shadowing or interview data. I also provide a confirmatory example for each enabler and collaborative activity from the member-checking interviews. Examples from the observation, shadowing and interview data are provided by both the site 1 and site 2 data (parent study); the member-checking interviews were only completed with clinicians from site 1.

In Table 10, there are ten enablers: active listening, approach, coordinate work, intraprofessional consult, invitation, nonverbal accessibility, reflexive question, send page/call, validation, and verbal accessibility.

Table 10

IPC Task List Enablers

Enabler	**Definition**	**Example**	**Member-checking Interview**
Active Listening	Attentive listening when another professional is communicating (eye contact, not multitasking).	"I love when the doctors round. I'll listen to a doctor round on a patient who's not my patient…You know what I mean? I'll just sit and I'll just listen…Just to get a different …get a different perspective…"- Site 1 Interview RN 3 Fellow stops Attending to give update on new patient. While describing the patient, two RNs turn from the computers and listen to the conversation. -Site 1 Observation 3 RN interrupts MD, who is briefing. She corrects him because there have been recent developments. MDs are attentive to her information. -Site 2 Observation 6	"Like I feel like most of the time, we'll stop what we're doing and pay attention to them [Medical team] …It's almost like a respect thing kind of too…And I think everybody does a pretty good job of that." RN Interview
Approach	Deliberately walking up to another professional to engage in a collaborative activity.	Vent is still alarming. RT goes up to Resident who is sitting at the computer and says, "She keeps biting her tube" - Site 1 Observation 3 "…but you know for a fact that when you check a gas, like I'm walking up to my therapist honestly before I walk up to my physician with it, just because they…I just trust them. Like hands down, I trust them 100% with my vent…" -Site 2 Interview RN 2	"I usually walk up and verbally talk to the doctor or the nurse first…I can't always find the doctor or resident because, you know, they have meetings, they have other patients, and they're gone. So, I will page them." RT Interview
Coordinate workflow	Identifying a mutual time that works for two or more professionals to complete a patient care task.	Patient has a chest tube. RN at door 'So what are we doing with the flush? I was told I needed to prepare it, but only the doctor can do the flush.' Fellow nods head and says he will do the flush. RN, 'Okay, [Fellow's first name]. I think its technically due at 10, but I'll page you when I have it set up.' Fellow, 'Okay, thanks [RN's first name] you're the best.'- Site 1 Shadowing MD 1 RN comes up to RT, 'Hey, when do we want to change the tape for him?' RT, 'Probably after you give his meds, when he's a little calmer.' RN, 'Okay, we'll you	"I'd say like as far as road trips go, that usually happens pretty well. Sometimes like there's that lack of coordination where the RT is off doing like something else, and then we're left like not having them at the moment. But as long as…IR, CT, whatever gives us a big enough timeframe, then I think

		let me know what works best for you. You're the one with 10 patients.' RT nods head…-Site 1 Shadowing RN 2	the coordination works better." RN Interview
Intra-professional Consult	Seek input from a fellow professional (i.e. RN to RN, RT to RT, MD to MD) to clarify a concern/decision before contacting another professional.	RN comes up to RT about patient who is waiting to go to the cath lab and says the transplant coordinators said the patient needs a bone scan, but the lab where these are performed do not have oxygen supply. [RT says] 'I wonder if this test can be waived' RN 3 shakes head in agreement and walks toward nursing station. RT follows behind and runs into head RT and asks if he has ever had a patient in a similar situation…Attending walks by. RT turns toward Attending and says, 'Hey why are we getting a bone scan on her?'-Site 1 Shadowing RT 2 "If I'm not getting what I need from the resident, and that's probably after I've made like multiple attempts to talk to the resident, I will eventually go to the Attending, or maybe I'll go to my charge nurse first and see if she can walk up to the resident and talk. I'll probably do that most likely before I would actually go to the Attending themselves."-Site 2 Interview RN 2	"If I have a problem with a patient on a vent, I will, you know, do what I can do to maybe fix it, but I have a supervisor that I will go to him, like 'Hey, what do you think about this before I go to the doctor about this? You know, what do you think? Is there anything that I'm missing, or is there anything that I can add to it?' And, you know, he'll give me his input. I mean he has years of experience. He'll be like, 'Yeah, you know, let's try this.' And it'll work and I'll let the physician know, 'Hey, this is what we're doing.' Or he'll be like, 'No, I don't know what we need to do. We need to come up with an alternative plan.'" RT Interview
Invitation	Explicit ask for participation from one professional to another professional.	RN is in rounds, standing at door next to Attending with arms crossed. Family member is also standing next to RN listening to rounds…Resident providing update on patient assessment. Following assessment, Attending says, "[RN's first name] anything else for me?" -Site 1 Shadowing MD 1 Initially, RN is not engaging in the conversation about whether patient should be comfort care. Following goals of care conversation, Attending turns to RN, "Anything nursing wise?" -Site 2 Observation 4	"Yeah, I think like inviting participation from another professional. I think that happens a lot. Like when you notice something like bedside, and like you need like their opinion on something or, you know, like you need them to do something" RN Interview

Nonverbal Accessibility	Clinician positioning him/herself in a particular location to indicate he/she is available to another professional.	"We typically do the extubation. The nurse is usually in the room. I haven't seen too many nurses that aren't in the room when we do it, but the Fellow has to be somewhere on the unit, at least. Usually they're at bedside, too. A lot of times the intern and resident or medical student will be in there, too."-Site 1 Interview RT 1 Move to room 3. MD is briefing…RN arrives partway through the briefing and stands by MD. -Site 2 Observation 6 RN about to leave unit, peeks head into room where RT is still working with the patient. Sees that HR and BP are elevated. RN walks into room and stands next to RT. -Site 1 Shadowing RN 1	"Accessibility is huge. I tell my residents this all the time. So, when you hide in your call room…You're not going to get more questions…but positioning yourself in a location is very important, I think." Fellow Interview
Reflexive Questioning	Asking another professional to explain rationale behind a decision. An approach to encourage further discussion between professionals when there is disagreement.	"They're [Nurses] just going to question you and they can ask you, 'I understand you want this done, but can you explain to me why you want it done?' A lot of that comes from medical knowledge, and you have to be able to explain it to them. Our nurses…The ICU definitely asks why something is being done the way it is being done…"-Site 2 Interview MD 1 RT discussing chronic nature of patients on unit and says, 'Sometime I get so frustrated with the docs, like WHY do you offer futile things to these chronically ill patients? ...I usually present it as a question. Like we got this, this, and this going on… [widens eyes] so why are we doing this? You know I try to use it as a teaching moment, please explain to me your rationale behind this?'-Site 1 Shadowing RT 2	"And our nurses actually do this to us quite a bit, where they'll say like, 'Can you show us data or studies supporting the use of Precedex over propofol?'…There are many other questions that we don't have data on that are harder. But, yeah, I think the really keen ones will be like, 'Oh, like what's the issue of that?'" Fellow Interview
Send page or call	Using a mode of information technology to contact another professional.	Lab tech delivers ABG RN looks over lab values and looks very confused.…RN looks down hall, no physicians in sight. RN sits at the computer and begins typing a page to the physician. -Site 1 Shadowing RN 2	"Paging or calling other professionals. Well, we definitely do that. Less so, again, with like nurses or RTs currently in the unit, probably RTs

		Medical team standing outside room of patient. Senior resident calls patient's RN on her portable phone. -Site2 Observation 1	more since they're always running around and it's harder to find them…" Fellow Interview
Validation	Providing verbal or nonverbal (i.e. head nod) endorsement to another professional.	Rounds start…Resident continues to update on assessment. RN adds, 'During report, overnight nurse and I were discussing that we think it would be a good idea to transition patient back to home Fentanyl patch and get him off IV.' Resident nods in agreement and repeats, 'Good call, good call.'-Site 1 Observation 1 …RN reads off [checklist]. Begins by saying she turned off patient's propofol. Attending nods head in approval and says, 'Sounds good that was going to be my request.' -Site 2 RN Shadowing 1	"…And this is…This is what we try and teach residents all the time. It's like our nurses are excellent, and so if they're coming to you with a problem or suggestion, it's a big deal…And it's like, even if you don't know the answer or we don't know what to do, it is a valid concern and we should at least identify it as a problem, even if we don't have great solutions." Fellow Interview
Verbal Accessibility	Clinician explicitly stating that he/she is available to another professional.	"…So usually the charge nurses that have had more experience with this…They're like, 'We've been through this…We're fine.' I'm like, 'okay, okay. Sounds good, sounds good. I'm just gonna…You know, I'll be over here right now.' Or if there's someone that's upset with the Fellow. They'll be like, 'Just stay on the other side of the unit.' I'll be like, 'Got it. I'm on the other side of the unit. If you need me, let me know.'"-Site 1 Interview MD 1 "…And they [Residents] kind of just say, 'Okay. I'm gonna be around if you need anything or if you think the family wants to talk to me, let me know. Otherwise, I'm just gonna go…I'm gonna go on. I'm gonna do my other responsibilities.'"-Site 1 Interview RN 3	"Yeah, so I think I've heard people say… 'You know, I'm sitting right in front of like so and so's room. So, when you come by, like I'll be here.'…That may be hard to do, or like 'page me if you can't find me.' I think most people are pretty good at that." Fellow Interview

In Table 11 there are eight collaborative activities: correction, fill in the gap, information exchange, negotiation, provide help, socializing, teach or train, troubleshoot.

Table 11

IPC Task List Collaborative Activities

Collaborative Activity	**Definition**	**Example**	**Member-checking Interviews**
Correction	Inserting the "correct" or most up to date information if the info provided by another professional is incorrect.	Attending: Did she fail her last trial?" Resident, "yeah she did." Attending, "How did we know she failed?" Resident: "She got hypercapnic" RN interjects: "Yeah, but she is on 5/5 now and minute ventilation of 3.5." -Site 1 MD Shadowing 1 Attending asks if patient has a fever. Resident says no, senior resident confirms. RN inserts, "No he does have a fever now, he's at 38.5." Senior Resident replies, "Oh I was not aware of this." -Site 2 Observation 4	"Corrective clarification. Yeah, we do that. We all hear different things from family, or we read in the chart… no one reads every single note, especially if the patient has been here a long time, but, …they may have gotten transfer of information from a resident on the floor or heard something from the family…" Fellow Interview
Fill in the gap	Stepping-in or supplementing another professional's transfer of information.	[In rounds] Resident begins providing assessment. When he gets to the respiratory system, says vent settings and then hesitates and looks at RN. RN responds, "Vent is 30% and 5/5." -Site 1 MD shadowing 1 The group [patient's care team] enters the room, and the Attending asks the Resident a question, which the RN answers because the MD looks confused. -Site 2 MD shadowing 1	"So, I think constantly we're…trying to fill in each other's gaps about patient backgrounds, which we often don't know a lot about when they first come in. We stabilize them, and then with time, we start picking up more on like the social aspects…" Fellow Interview
Information exchange	Short interaction during which objective clinical information and/ or a subjective assessment is communicated by one professional to another.	RN turns towards Resident. Resident to RN: "How long has he been on nasal cannula?" RN: "Almost 2 hours." Resident to RN: "How much is he on? 6 liters?" RN1: "Yeah, 6 liters…so we're going to d/c the foley? And D/c the central line…anything else?" Resident moving toward door, standing	"…So, for the information exchange, during rounds is typically when we do it, but even before rounds, when I start my shift, I go through and I have so many vented patients. We have protocols that we follow in order to

		with arms crossed: "Did we get any IVs on him?" Charge Nurse: "I'm getting one right now." Resident "okay, well he looks good. Thanks." -Site 1 Observation 2 [On rounds] RN: "SAT and SBT done. Increased secretions, increased coughing, no cuff leak. CAM negative and receiving passive ROM in bed." Attending asks about length of SBT. RN indicates it wasn't as long as yesterday's SBT. -Site 1 Observation 5	determine whether I can do SBTs…or not. So, I will go and I will talk to the nurse. I'm like, 'Hey, are they on any sedation? Are they on any kind of pressors, anything that would contradict me doing an SBT?' And we'll have a short conversation, and if they're not, then I'll start an SBT before we round." RT Interview
Negotiation	A dialogue between two or more professionals to achieve a consensus regarding a change in a patient care's plan/management.	"This patient is going crazy, crazy, crazy. Like no one is paying attention." It's like, 'Okay. What . . . What do you want? This is what I'm willing to tolerate. This is what I want the patient to be at. I hear what you're saying. I hear that you're really frustrated. So, what if we do X, Y and Z, and we have a plan?' And I have found that if you approach it like, 'This is me; where are you? This is a medium ground; does that work for you' and you circle back that usually satisfies about 99% of them."-Site 1 MD Interview 1 Resident makes a change in dose [for pain medication], adds a prn order and asks RN if that is reasonable. RN agrees and Resident says, "let me know if that doesn't work and we can readjust." -Site 2 Observation 1	"Negotiation does happen quite a bit because there are many ways to skin a cat, and in our very highly emotional setting where people have very strong opinions, the dialogue can be quite varied, and people have very strong opinions…depending on kind of…where you're coming from, we don't uncommonly disagree… …There is negotiation, and I think it often goes fine…Commonly I'll say, 'Let's try X, Y, Z. and if it doesn't work, we can always go back to A, B, C.'" Fellow Interview

		RN "Anyway, this [patient] …I can't suction anything on him. He's more awake, but satting at 88 to 89, want to put him back on [full vent settings]?" RT: "Yeah, I can do that right now." RN: "Do you want me to get a gas on him?" RT: "What do you think?" RN: "I don't think were gonna change anything, so I guess we can hold off." RT: "Yeah, I agree. That's fine with me." -Site 1 RT shadowing 2	
Provide help	Assisting another professional in completing his/her professional duties/responsibilities.	RN & RT are together doing a respiratory treatment with the patient while rounds is going on and mom is participating in rounds. RN then turns on the percussion bed. -Site 1 RT shadowing 1 In the room, RN and RT begin to work on Patient…they adjust her bed for the ABG… RT works with RN without having explicitly said anything to each other, to stabilize the patient and get the ABG. BP is too low to find the artery by palpation, so RT gets a doppler ultrasound to locate it…RN helps hold the patient still for RT while she locates the artery and draws the blood.-Site 2 RT shadowing 1	"I think providing help probably happens more between… nurse to like RT and vice-versa. Like I mean, we help the doctors with like their central line placement and like stuff like that, like help get the stuff together for that." RN Interview
Socializing	Engaging in non-clinical related conversations or making jokes with one another.	"I think there's a mutual respect between all of us …the whole team. I think that part of that too is that when we do have down time, we sit together and talk and joke and, you know, talk about our families and vacations that we're gonna go on or have gone on and, you	"Yeah, we do that [socializing]. It's good to do that, too. I agree. I mean if you get along with other people, it works out…It is something that is important…"RT Interview

		know, share tips like, 'Oh, when my kid wouldn't do this, this is what I did.' So like you get to know them. You get to know the people you work with because you spend sometimes more time with them than you do your family."-Site 1 RT Interview 2 "So like generally my approach has been to always get to know the nurses. So even if it's just sitting in the break area and just talking just to find out, 'Do you have kids?' 'Where are you coming from?' 'How long have you been in the unit?'…And I think it makes it easier to then …When you have a situation that emerges, you've already had some sort of communication with each other. You're not just like, 'Hi. Do this now. Thanks. I'm the fellow, by the way.'"-Site 1 MD Interview 1	
Teach or Train	Provide didactic training or hands-on skill training to another professional.	RN is sitting at the computer and turns to RT, "Here's a question for you… What's with this AVAPS setting? How are they different than BiPAP?" … RT and RN engage in a back and forth conversation where RT briefly describes difference between AVAPS and BiPAP… RN: "Why are we using this?" Other RN chimes in. RN, "Yeah I don't know what it's all about that's why I'm asking the expert" [points to RT] RN: "Here's my second question for you, how do you wean on that setting?" …RT does describe briefly how to wean, but emphasizes that this mode prevents patients	"All the time. All the time…A lot of the doctors coming in. They don't know a lot about the vent at all. So this is their time to learn, too, and it's our job because we have the most experience with it. So, we show doctors all the time, new nurses coming on. Kind of like, we want the nurses to know also what we're doing and what to look for if we're not there…So we do a lot of training with nurses, new nurses…" RT Interview

		from being transferred to certain units. - Site 1 RT shadowing 2 RN asks Attending about auto-peeping and Attending is teaching Resident, RN and sub-Is about autopeeping. RN is actively engaged, asking questions about it. -Site 1 Observation 4	
Troubleshooting	After a patient care issue arises, two or more professionals engage in a dialogue to identify the root cause of the issue and propose potential solutions.	RN comes up [to Resident], almost frantically. Stands right next to Resident who stops typing, but still at computer. Resident to RN: "What's up?" RN describing to Resident changes in patient's MAP and different readings between arterial line and non-invasive BP cuff. RN expresses that she is concerned because she gave patient a bolus but he is not responding. Says she went up on levophed and MAP on cuff responded. Resident responds… "yeah, that sounds confusing." RN: "I guess what I'm trying to say is I'm not really sure what's going on" Resident: "Well I can replace the art line if you think that's what we need to do. Let's wait and get an ABG and we're gonna do an EDM(esophageal Doppler monitoring). We'll see where his lactate is heading. If his lactate is good, I guess we'll believe the art line." -Site 1 Observation 2 RN enters patient's room with supplies. Exits the room and is stopped by the Intern who is standing at the resident station next to a COW. Intern is updating RN on patient's condition related to change in	You know, as far as troubleshooting goes, if any problems arise, I have protocols where I can make certain changes on my own, but the doctors are there, and I say, 'You know, this is what's going on.' Then we kind of give each other input, and then we decide, you know, why it's happening, and then we take a course of action." RT Interview

		lab values. Resident relays to RN that an LR bolus was just ordered. Intern says to RN, "Sorry, I'm like freaking out." … RN says changing patient's fluids was "on my list of things to ask in rounds." … RN asks intern if she wants her to turn off sedation before rounds to see if that is contributing to the hypotension. Intern says that's a good question to ask the Attending… -Site 2 RN shadowing 1	

Aim 2

As described in the methods section, the ten enablers and eight collaborative activities were included as individual items on the time-motion tool; the tool was then used by observers to collect data on the process of interprofessional collaboration in the care of mechanically ventilated patients.

The second aim of this study was to determine the feasibility of using time-motion methodology to measure the process of interprofessional collaboration in the care of mechanically ventilated patients. We were able to feasibly collect time-motion data on the IPC process. We recruited 18 different clinicians to participate in 18 separate observations over a nine-week period. Specifically, we sampled six nurses, six respiratory therapists, and six physicians. All clinicians were recruited from a 20-bed medical ICU at an academic center in Southeastern Michigan. We collected approximately 61 hours of observation across weekdays and weekends, divided proportionally among the three clinician roles. All data were collected in the morning hours between 0700 and 1230. By observing the same quantity of nurses, respiratory therapists, and physicians over the same timeframe, we can directly compare how these specific clinician roles engage in the process of interprofessional collaboration in the care of mechanically ventilated patients using the collected time-motion data. After reviewing the process, we did identify areas for improvement to enhance future data collection. In the following section, I present the results of the time-motion study followed by a description of the strengths and challenges encountered by the observers during data collection. Potential strategies to mitigate the identified challenges in future work are also included.

Characteristics of Study Population and Observation Sessions

Table 12 displays the characteristics of the clinicians who participated in the observations. The level of experience varied between clinicians with half identifying as late career (over 10 years' experience) and approximately a quarter identifying as early career and midlevel career, respectively. The median time spent working in the unit was 7 years. 44% of the participants were male.

Table 12

Clinician Demographic Info

N=18 clinicians	
Level of Experience (n (%))	
Early Career (< 4 yrs. experience)	4 (22.22%)
Mid Career (4-10 yrs. experience)	5 (27.78%)
Late Career (> 10 yrs. experience)	9 (50.00%)
Number of years working in site ICU (Median, IQR)	7 (0.5-16)
Age (Median, IQR)	33.5 (31-44)
Gender (n (%))	
Male	8 (44.44%)
Female	10 (55.56%)
Race (n (%))	
Asian	1 (5.56%)
Black or African American	1 (5.56%)
White	16 (88.89%)

A summary of the observations is presented in Table 13. As indicated in Table 13, we completed approximately 61 hours of observation total and observed clinicians participating in the care of 54 mechanically ventilated patients. The hours of observation and total mechanically ventilated patients cared for by clinician role are also displayed. Additionally, the median number of MV patients cared for by clinician per observation session is included. The median number of mechanically ventilated patients cared for by RNs per observation session was one patient compared to four patients for both MDs and RTs.

Table 13
Summary of Observations

Clinician Observations (N=18)	
Total time (hrs.)	60.83
Mean Duration of Individual Observations (SD)	3.38 (0.54)
MV Patients Observed (n)	54
MD Observations (N=6)	
Total time (hrs.)	19.58
Mean Duration of Individual Observations (SD)	3.26 (0.25)
MV Patients Observed (n)	23
MV Patients per Observation (Median, IQR)	4(3-4)
RN Observations (N=6)	
Total time (hrs.)	20.50
Mean Duration of Individual Observations (SD)	3.42 (0.47)
MV Patients Observed (n)	6
MV Patients per Observation (Median, IQR)	1(1-1)
RT Observation (N=6)	
Total time (hrs.)	20.75
Mean Duration of Individual Observations (SD)	3.46 (0.82)
MV Patients Observed (n)	25
MV Patients per Observation (Median, IQR)	4 (4-4)

Table 14 describes the distribution of observation hours across the three observers who participated in the data collection. Together, Observer 1 and 2 completed a third of the observations with Observer 3 completing the remaining observations.

Table 14
Summary of Observations by Observer

Observations (N=18)	
Time (hrs.)	60.83
Observer 1 (N=3)	
Total Time (hrs.)	11.67
Mean Duration of Individual Observations (SD)	3.89 (0.19)
Observer 2 (N=3)	
Total Time (hrs.)	9.5
Mean Duration of Individual Observations (SD)	3.17 (0.58)
Observer 3 (N=12)	
Total Time (hrs.)	39.66
Mean Duration of Individual Observations (SD)	3.31 (0.54)

Frequency of IPC Behaviors

In the following section, I present frequency tables and paired bar graphs to display how often clinicians engaged in the IPC process. The enablers and collaborative activities are grouped together as IPC behaviors; separate frequency tables are presented for the enablers and collaborative activities as indicated to increase the readability of the data.

In total, we observed 907 IPC behaviors across all the observations. Table 15 presents the observed frequencies for the individual enablers across all the observations. The percentages presented are in reference to the entire IPC process (i.e. sum of total enablers and total collaborative activities). Among the enablers, active listening, nonverbal accessibility, approach and validation were the most frequently observed.

Table 15

Frequency of Individual Enablers Across all Observations (n=288 enablers)

Enablers	n (%)
Active Listening	87 (9.59%)
Approach	37 (4.08%)
Coordinating Work	18 (1.98%)
Intraprofessional Consult	11 (1.21%)
Invitation	28 (3.09%)
Nonverbal Access	55 (6.06%)
Reflexive question	0 (0.00%)
Send Page	8 (0.88%)
Validation	37 (4.08%)
Verbal Access	7 (0.77%)

**Note:* Percentages based on total IPC behaviors across all observations

Table 16 presents the observed frequencies for the individual collaborative activities across all the observations. The percentages presented are in reference to the entire IPC process (i.e. sum of total enablers and total collaborative activities). For the collaborative activities, information exchange, socializing and provide help were the most frequently observed.

Table 16

Frequency of Individual CAs Across all Observations (n=619 CAs)

Collaborative Activity	**n (%)**
Correction	8 (0.88%)
Fill In	7 (0.77%)
Info Exchange	406 (44.76%)
Negotiation	17 (1.87%)
Provide Help	34 (3.75%)
Socialize	128 (14.11%)
Teach or Train	9 (0.99%)
Troubleshooting	10 (1.10%)

Note: Percentages based on total IPC behaviors across all observations

Figure 3 and Figure 4 display the percentage frequency distribution for IPC behaviors across all the observations. Figure 3 compares the total percentage of observed enablers to the total percentage of observed collaborative activities (i.e. sum of all enablers and collaborative activities, respectively) and Figure 4 displays the percentage of individual enablers and collaborative activities across all observed IPC behaviors. As indicated in Figure 3, most observed IPC behaviors were classified as collaborative activities (68.25%) compared to enablers (31.75%). Among the specific types of IPC behaviors, information exchange was the most frequently observed IPC behavior, representing almost 45% of all observed behaviors (Figure 4). This is followed by socializing and active listening which represent 14% and 10% of total observed behaviors, respectively. Behaviors that were not observed as frequently (i.e. less than 1% of observed IPC behaviors each) include sending pages, verbal accessibility, correction, fill in the gap, and teach/train. Of note, the enabler reflexive question is not included in the bar graph because it was not observed in any of the observations.

Figure 3 *Percentage Frequency Distribution for Enablers vs. CAs Across All Observations (N=907 IPC behaviors)*

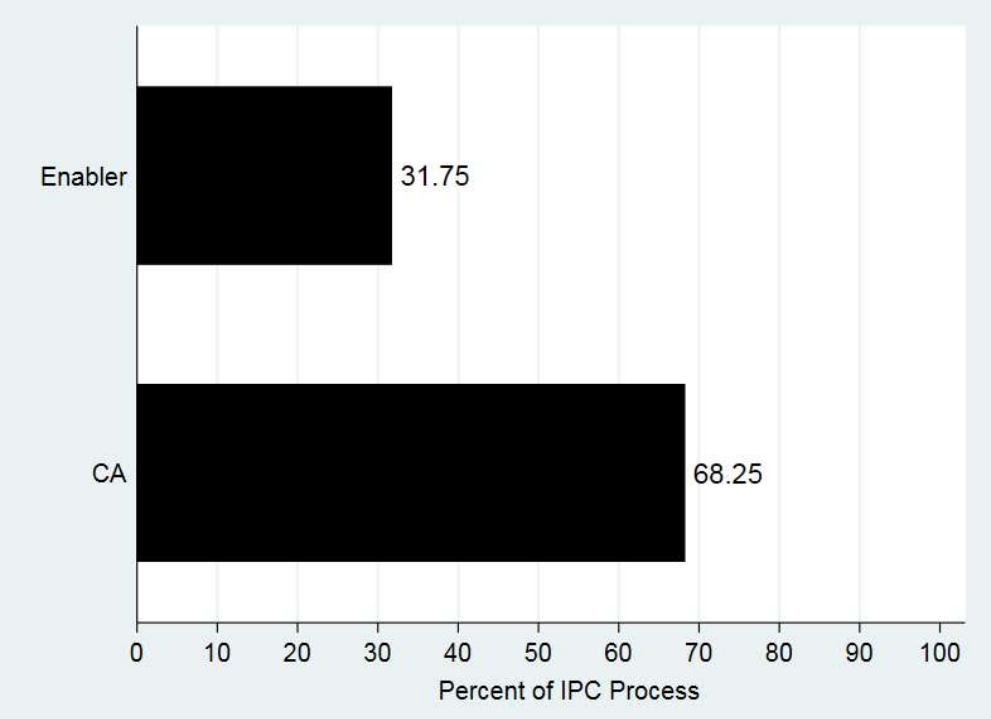
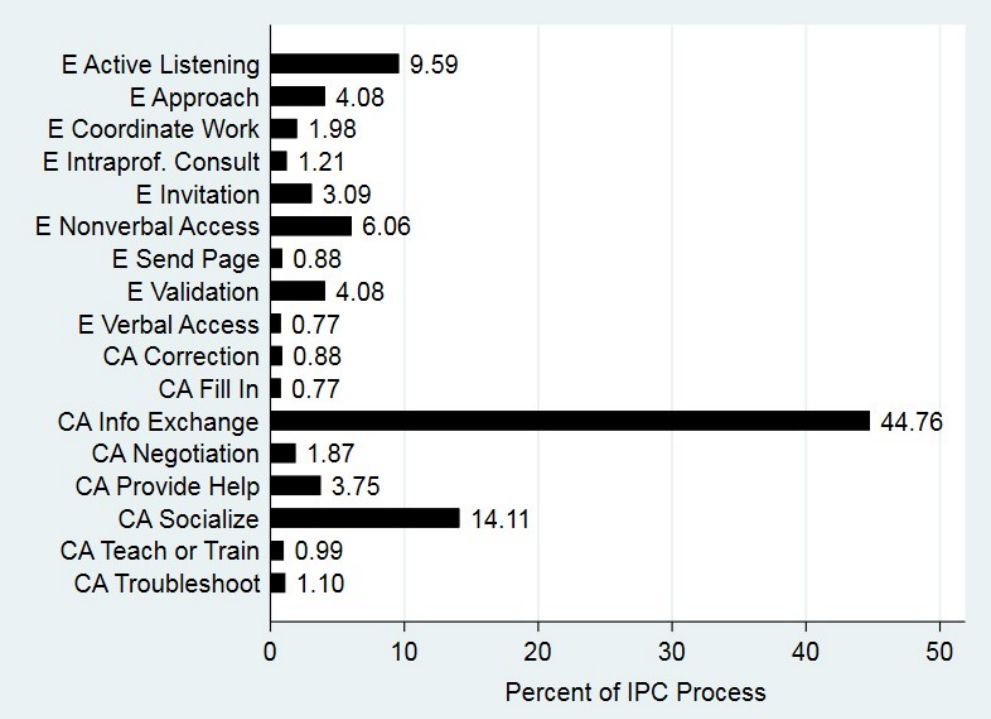


Figure 4 *Percentage Frequency Distribution for IPC Behaviors Across All Observations (N=907 IPC behaviors)*



**Note:* Percentages based on total IPC behaviors across all observations

Table 17 presents the total frequency of observed enablers and the total frequency of observed collaborative activities (i.e. sum of all enablers and collaborative activities, respectively) for each clinician role. As indicated in the totals, we observed 198, 227, and 482 IPC behaviors across the MD, RN, and RT observations respectively. The percentages displayed in the table are in reference to the entire IPC process per clinician role (i.e. the denominator differs per clinician role). For example, we can interpret the displayed data as 40% of IPC behaviors observed during the MD observations were enablers and 60% of IPC behaviors observed during the MD observations were collaborative activities.

Table 17

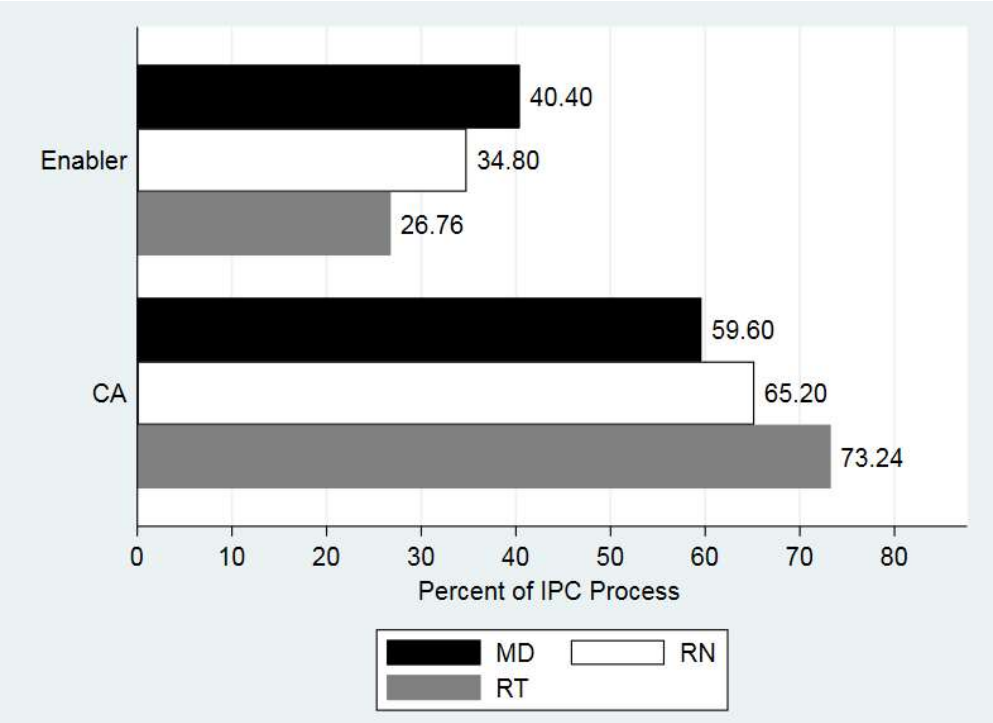
Frequency of Enablers and CAs By Clinician Role

IPC Behavior	MD (n (%))	RN (n (%))	RT (n (%))	All Clinicians (n (%))
Enablers	80 (40.40%)	79 (34.80%)	129 (26.76%)	288 (31.75%)
CAs	118 (59.60%)	148 (65.20%)	353 (73.24%)	619 (68.25%)
Total IPC Behaviors	198	227	482	907

Note: Percentages based on total IPC behaviors observed within each clinician role

Figure 5 displays the percentage frequency distribution presented in Table 17 in a bar graph. Across all clinician roles, enablers were observed less frequently than collaborative activities. Of the observed behaviors within each role, respiratory therapists engaged in collaborative activities the most (73%) compared to MDs (60%). Conversely, of the observed behaviors for each role, RTs engaged in enablers least often (27%) compared to MDs (40%).

Figure 5 *Percentage Frequency Distribution for Enablers vs. CAs By Clinician Role (n=907 total IPC behaviors; n=198 for MDs, n=227 for RNs, n=482 for RTs)*



*Note: Percentages based on total IPC behaviors observed within each clinician role

Table 18 displays the total observed frequencies for the individual enablers to collaborative activities by clinician role. The percentages displayed in the table are in reference to the entire IPC process per clinician role (i.e. sum of total enablers and total collaborative activities for each clinician role). Among the IPC behaviors, active listening was the most frequently observed enabler for the MDs followed by invitation and validation with each enabler representing approximately 17%, 11%, and 8% of total observed behaviors, respectively. Across the RN observations, nonverbal accessibility was the most frequently observed enabler with approximately 11% of observed IPC behaviors being nonverbal accessibility. Active listening was the second most frequently observed enabler for RNs at 8% of total IPC behaviors. There was more variability in observed enablers across the RT observations with approximately 7%, 6%, and 5% of observed IPC behaviors being active listening, nonverbal access and approach, respectively. Of note, only RNs used the "send page" enabler, representing 4% of total observed IPC behaviors. Additionally, verbal accessibility was only observed by the RTs (1.5% of total RT observed IPC behaviors). The enabler reflexive question was not observed in any of the MD, RN, or RT observations.

Table 18

Frequency of Individual Enablers by Clinician Role (n=288 total enablers; n=80 for MDs, n=79 for RNs, n=129 for RTs)

Enablers	**MD (n (%))**	**RN (n (%))**	**RT (n (%))**
Active Listening	34 (17.17%)	20 (8.81%)	33 (6.85%)
Approach	5 (2.53%)	8 (3.52%)	24 (4.98%)
Coordinating Work	3 (1.52%)	3 (1.32%)	12 (2.49%)
Intra Consult	0 (0.00%)	5 (2.20%)	6 (1.24%)
Invitation	21 (10.61%)	1 (0.44%)	6 (1.24%)
Nonverbal Access	1 (0.51%)	25 (11.01%)	29 (6.02%)
Reflexive question	0 (0.00%)	0 (0.00%)	0 (0.00%)
Send Page	0 (0.00%)	8 (3.52%)	0 (0.00%)
Validation	16 (8.08%)	9 (3.96%)	12 (2.49%)
Verbal Access	0 (0.00%)	0 (0.00%)	7 (1.45%)

Note: Percentages based on total IPC behaviors observed within each clinician role

Table 19 displays the total observed frequencies for the individual collaborative activities by clinician role. The percentages displayed in the table are in reference to the entire IPC process per clinician role (i.e. sum of total enablers and total collaborative activities for each clinician role). The observed frequencies for information exchange were similar for all roles, representing 44-45% of observed IPC behaviors for MDs, RNs, and RTs. Socializing and providing help were also the second and third most frequently observed collaborative activities for MDs, RNs, and RTs, however there was greater variation in the percent of total IPC behaviors each collaborative activity represented for the different clinician roles. All collaborative activities were observed at least once by all clinician roles unlike the enablers which were not observed by all roles (e.g. send page, intraprofessional consult, verbal access, reflexive questioning).

Table 19

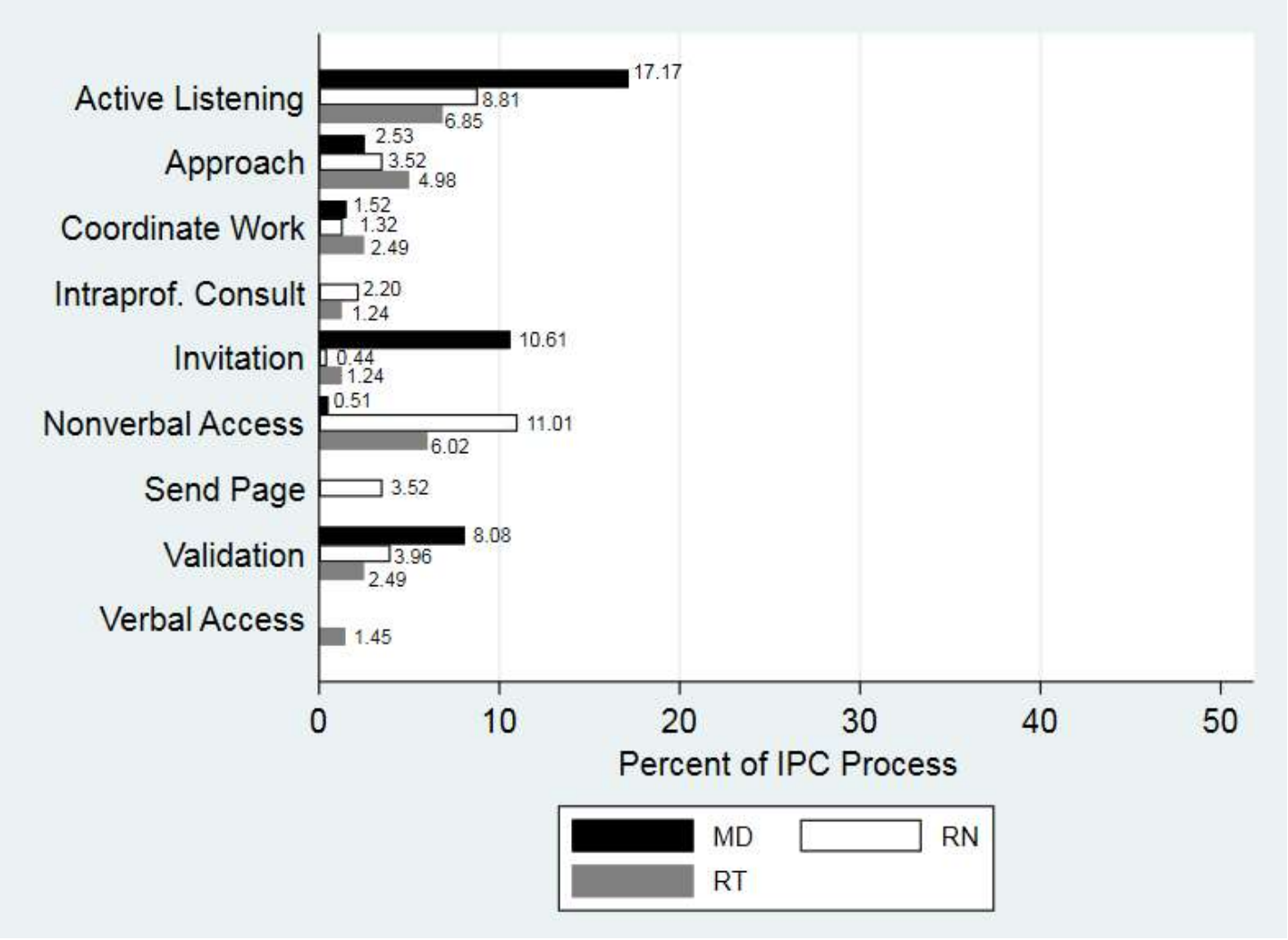
Frequency of Individual CAs by Clinician Role (n=619 total CAs; n=118 for MDs, n=148 for RNs, n=353 for RTs)

Collaborative Activities	**MD (n (%))**	**RN (n (%))**	**RT (n (%))**
Correction	1 (0.51%)	5 (2.20%)	2 (0.41)
Fill In	1 (0.51%)	3 (1.32%)	3 (0.62%)
Info Exchange	90 (45.45%)	102 (44.93%)	214 (44.40%)
Negotiation	3 (1.52%)	2 (0.88%)	12 (2.49%)
Provide Help	4 (2.02%)	7 (3.08%)	23 (4.77%)
Socialize	15 (7.58%)	27 (11.89%)	86 (17.84%)
Teach	2 (1.01%)	1 (0.44%)	6 (1.24%)
Troubleshooting	2 (1.01%)	1 (0.44%)	7 (1.45%)

Note: Percentages based on total IPC behaviors observed within each clinician role

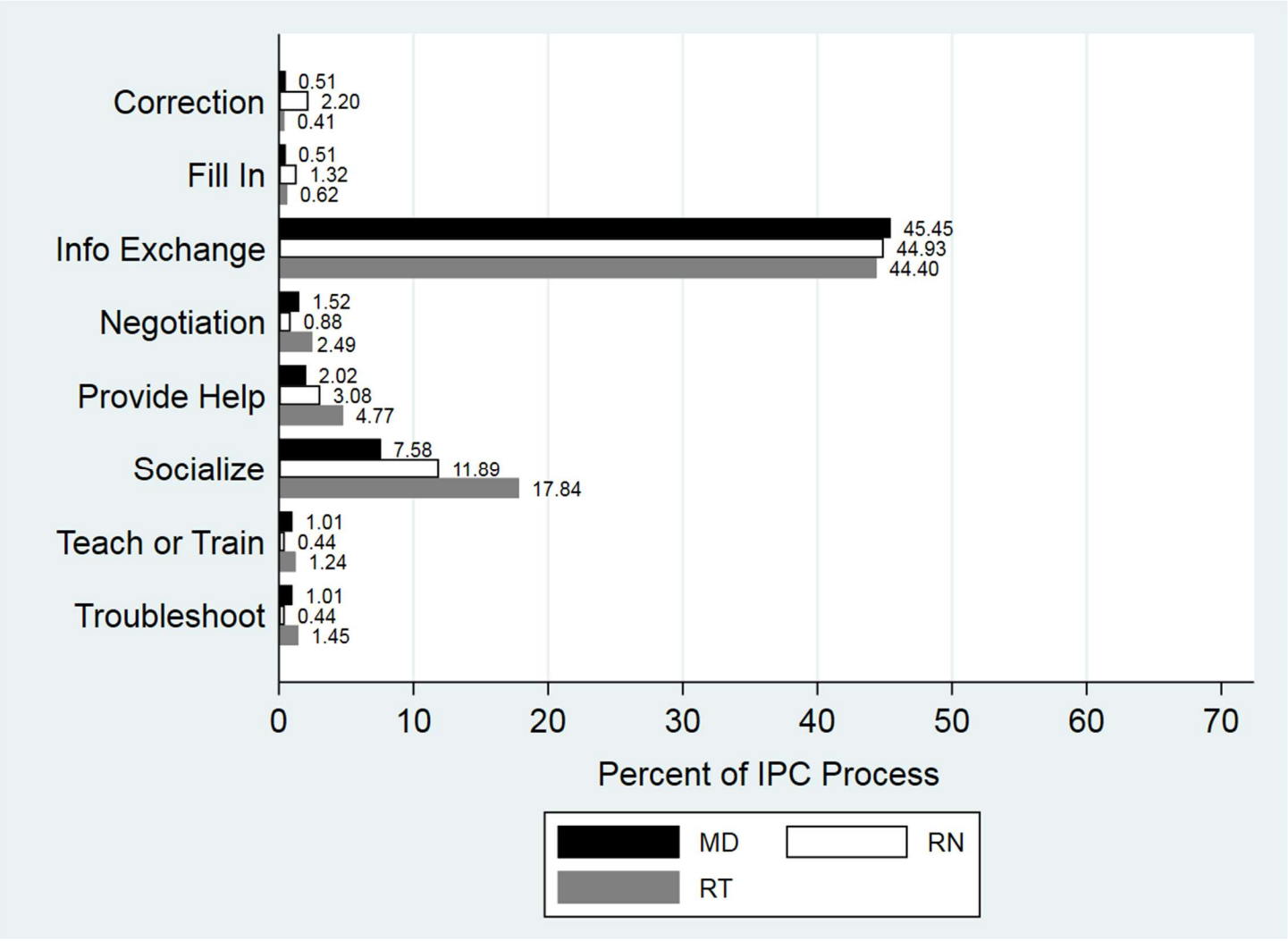
Figure 6 and Figure 7 display the percentage frequency distributions for the enablers and collaborative activities which are presented in Table 18 and Table 19.

Figure 6 *Percentage Frequency Distribution for Enablers by Clinician Role (n=288 total enablers; n=80 for MDs, n=79 for RNs, n=129 for RTs)*



*Note: Percentages based on total IPC behaviors observed within each clinician role

Figure 7 *Percentage Frequency Distribution for CAs By Clinician Role (n=619 total CAs; n=118 for MDs, n=148 for RNs, n=353 for RTs)*



*Note: Percentages based on total IPC behaviors observed within each clinician role

Duration of IPC Behaviors

In the following section, I present tables and bar graphs to describe the time spent in IPC behaviors. Table 20 presents the total IPC time collected for each clinician role and compares this time to the total observation time for each role. As displayed in the table, MDs spent approximately 4% of the observation time in IPC, compared to 12% for RNs and 20% for RTs.

Table 20
Percent of Observation Time Spent in IPC

	MD Time (mins)	**RN Time (mins)**	**RT Time (mins)**	**All Clinicians Time (mins)**
Total Observed IPC Time	44.05	145.97	242.18	432.20
Total Observation Time	1,174.80	1,230.00	1,245.00	3,649.80
% of Observation time spent in IPC	3.75%	11.87%	19.45%	11.84%

Table 21 and Table 22 display the mean time spent, in seconds, on each enabler and collaborative activity across all the observations. The standard deviation is also included to indicate variation in the reported time values. Among the enablers presented in Table 21, some behaviors utilized very little IPC time. For example, instances of invitation or validation lasted approximately 3 seconds, on average. Nonverbal enablers including active listening and nonverbal accessibility appeared to comprise of more time with each lasting 40-91 seconds per instance, on average. The standard deviations for select enablers, including active listening, intraprofessional consult, nonverbal accessibility, and verbal accessibility, are relatively high indicating wide variation in the actual time spent on each behavior over the observation period.

Table 21

Mean Time Spent in Each Enabler Across all Observations (total time IPC time (in secs) =25,932)

Enablers	**Mean time (secs) (SD)**
Active Listening	39.86 (61.08)
Approach	7.30 (7.19)
Coordinating Work	6.78 (4.63)
Intraprofessional Consult	98.82 (250.58)
Invitation	3.12 (1.81)
Nonverbal Access	91.11 (126.39)
Reflexive question	0.00 (0.00)
Send Page	44.88 (16.95)
Validation	3.32 (2.51)
Verbal Access	11.86 (17.81)

Compared to the enablers, the time spent in each collaborative activity appears to be more homogeneous (Table 22). Providing help lasted approximately 51 seconds per instance, on average, which constitutes the most amount of time spent on a single collaborative activity. Among the activities of open communication, instances of negotiation and troubleshooting lasted longer, on average, compared to correction, fill in the gap, or information exchange. This also includes a wider range of time spent on these particular activities.

Table 22

Mean Time Spent in Each CA Across All Observations (total time IPC time (in secs) =25,932)

Collaborative Activities	**Mean time (secs) (SD)**
Correction	5 (3.66)
Fill In	7.29 (4.39)
Info Exchange	18.69 (22.74)
Negotiation	36.24 (38.52)
Provide Help	50.94 (70.47)
Socialize	37.45 (65.55)
Teach	16.22 (7.85)
Troubleshooting	35.60 (23.87)

Table 23 presents the mean time spent on the individual enablers by clinician role. Among the enablers, there is a distinct difference in average time spent in active listening between the different clinician roles with RNs and RTs spending 59-63 seconds in each instance of active listening, on average, compared to 8 seconds among the MDs. Average time spent in intraprofessional consulting by RNs appears to be inconsistent with time spent in other enablers. Average time spent in the remaining enablers, per instance, are relatively similar across roles.

Table 23

Mean Time Spent in Each Enabler by Clinician Role (total time IPC time (in secs) =25,932)

Enablers	**MD (mean time (secs) (SD))**	**RN (mean time (secs) (SD))**	**RT (mean time (secs) (SD))**
Active Listening	7.53 (7.83)	63.25 (92.40)	59.00 (55.35)
Approach	8.00 (13.44)	4.38 (4.78)	8.13 (6.23)
Coordinating Work	8.00 (6.00)	3.67 (1.15)	7.25 (4.81)
Intraprofessional Consult	0 (0.00)	186.00 (373.09)	26.17 (16.92)
Invitation	2.95 (1.80)	6.00 (0.00)	3.17 (1.72)
Nonverbal Access	72.00 (0.00)	90.16 (122.78)	92.59 (133.67)
Reflexive question	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Send Page	0.00 (0.00)	44.88 (16.95)	0.00 (0.00)
Validation	2.50 (0.97)	3.00 (1.66)	4.67 (3.77)
Verbal Access	0.00 (0.00)	0.00 (0.00)	11.86 (17.81)

Table 24 presents the mean time spent on the individual collaborative activities by clinician role. The average time spent in providing help (54-56 secs) and socializing (36-42 secs) was similarly higher for the RNs and RTs compared to the MDs (14-15 secs each). Time spent in negotiation averaged 36-38 seconds per instance across all three roles, however the standard deviation for the MDs and RTs was larger than the RNs indicating greater variability in actual time spent on this behavior. Across all roles, times spent in correction or fill in the gap were the lowest, lasting 10 seconds or less per instance, on average.

Table 24

Mean Time Spent in Each CA by Clinician Role (total time IPC time (in secs) =25,932)

Collaborative Activities	**MD (mean time (secs) (SD))**	**RN (mean time (secs) (SD))**	**RT (mean time (secs) (SD))**
Correction	2.00 (0.00)	5.40 (3.85)	5.50 (4.95)
Fill In	2.00 (0.00)	10.00 (4.36)	6.33 (3.51)
Info Exchange	17.91 (28.88)	22.52 (25.41)	17.19 (17.87)
Negotiation	36.33 (41.31)	38.00 (7.07)	35.92 (42.93)
Provide Help	14.25 (16.01)	54.00 (59.90)	56.39 (78.46)
Socialize	14.73 (24.29)	35.93 (41.97)	41.88 (75.32)
Teach	10.50 (2.12)	28.00 (0.00)	16.17 (7.55)
Troubleshooting	62.50 (28.99)	65.00 (0.00)	23.71 (12.83)

Figure 8 and Figure 9 display the proportion of total IPC time spent on the different IPC behaviors across all the observations. Figure 8 displays the total proportion of IPC time spent on enablers and the total proportion of IPC time spent on collaborative activities (i.e. time sum of all enablers and collaborative activities, respectively) and Figure 9 displays the total proportion of IPC time spent on the individual enablers and collaborative activities. As demonstrated in Figure 8, overall IPC time spent on enablers is still less than time spent on collaborative activities, however the difference is almost 10% less than the difference in observed frequencies of enablers vs. collaborative activities across all the observations. Information exchange (Figure 9) utilized the highest proportion of IPC time (29.26%) followed by nonverbal accessibility (19.32%) and socializing (18.48%). Behaviors that utilized a small proportion of IPC time (i.e. less than 1% of total IPC time each) include coordinating work, invitation, validation, verbal accessibility, correction, fill in the gap, and teach or train.

Figure 8 *Percentage Distribution for Time Spent in Enablers vs. CAs Across all Observations (n=432.20 total minutes in IPC)*

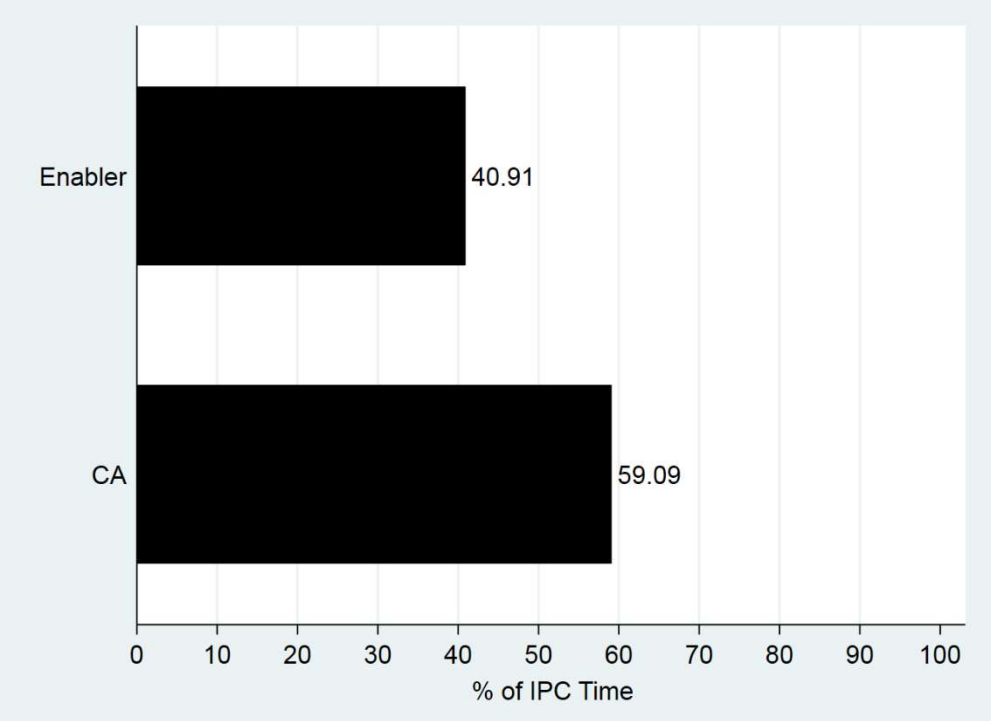
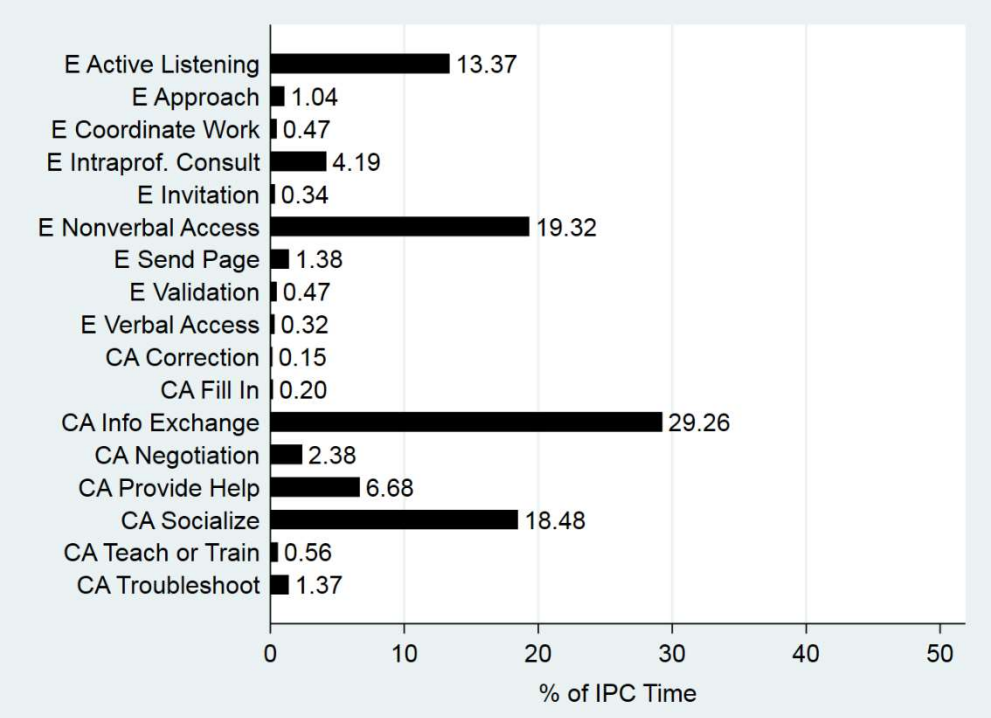


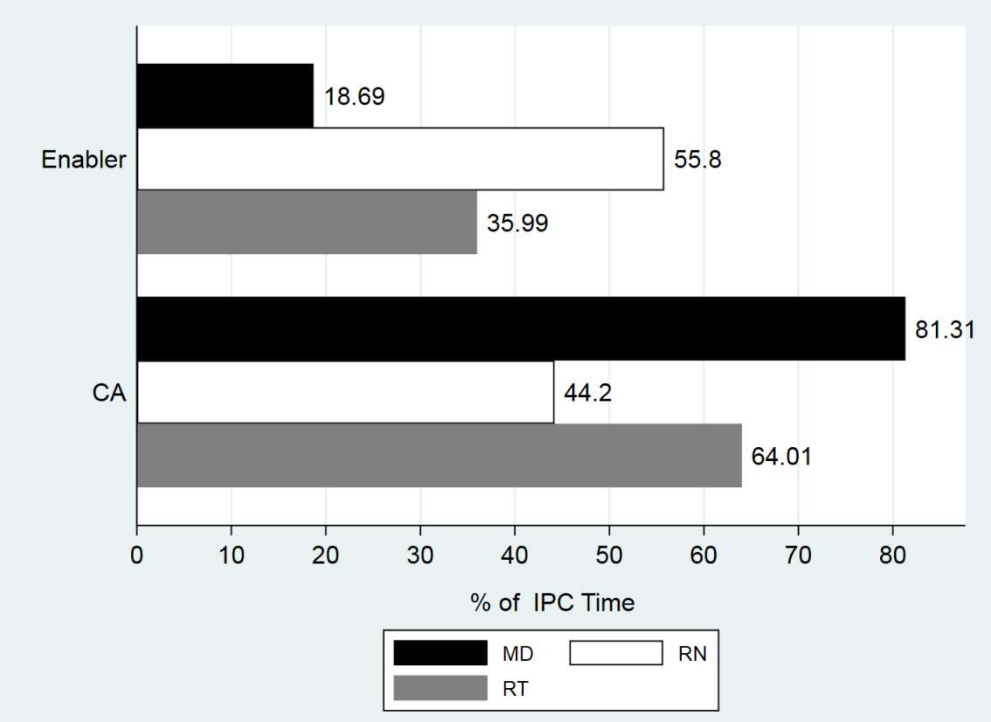
Figure 9 *Percentage Distribution for Time Spent in Each IPC Behavior Across All Observations (n= 432.20 total minutes in IPC)*



*Note: Percentages based on total IPC time across all observations

Figure 10 displays the total proportion of IPC time spent on enablers and collaborative activities by clinician role. MDs spent approximately 80% of their IPC time in collaborative activities and only 20% of their IPC time in enablers. RTs also spent more IPC time in collaborative activities (64%) than enablers (36%). RNs, conversely, spent more IPC time in enablers (56%) compared to collaborative activities (44%).

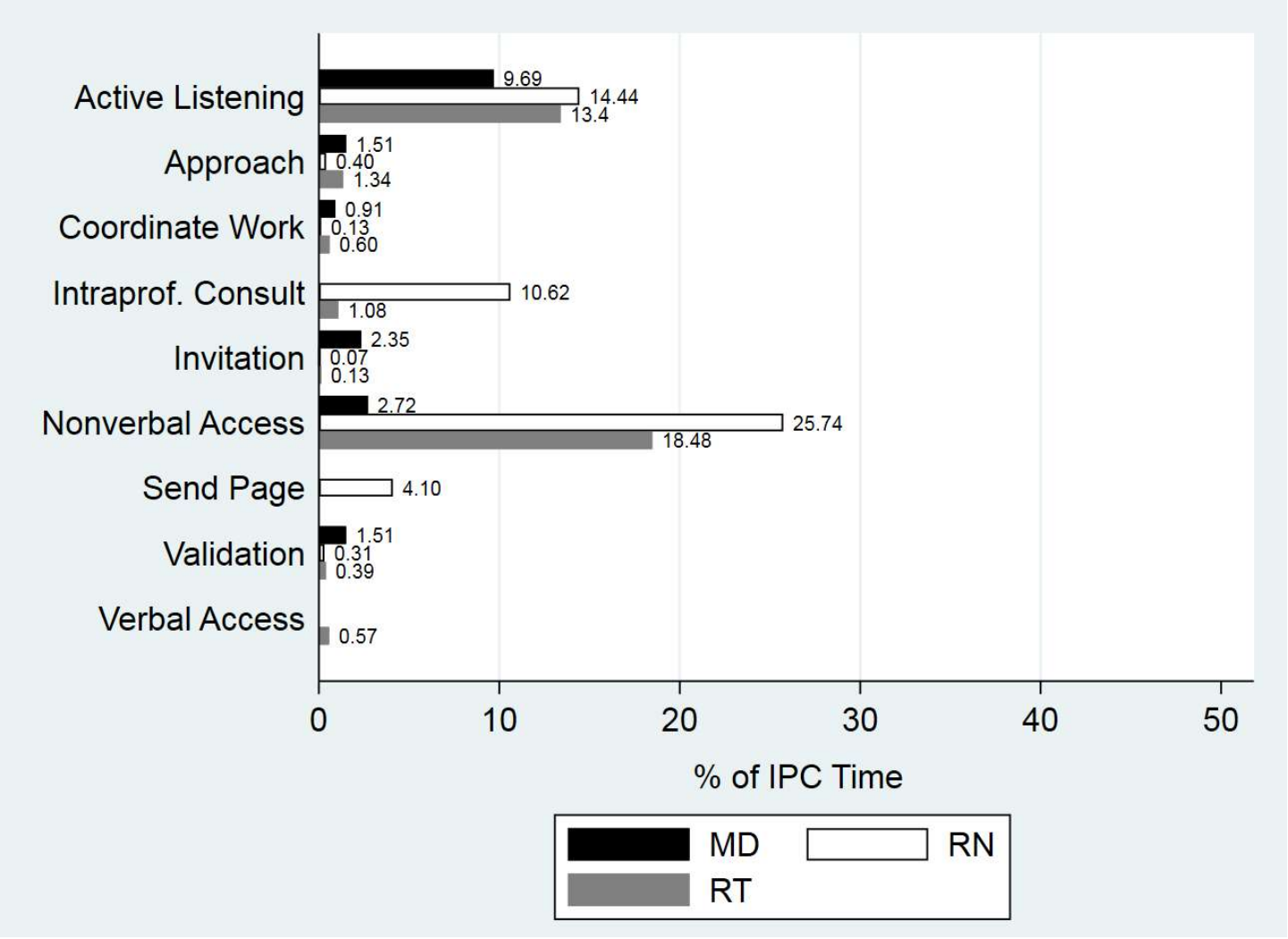
Figure 10 *Percentage Distribution for Time Spent in Enablers vs. CAs By Clinician Role (n=432.20 total minutes in IPC; n=44.05 mins for MDs, n= 145.97 mins for RNs, n=242.18*



Note: Percentages based on total IPC time within each clinician role

Figure 11 displays the proportion of IPC time spent in the individual enablers by clinician role. The percentages displayed are calculated by dividing the total time spent in each enabler by the total time spent in IPC by role. Among the enablers, nonverbal accessibility utilized the highest proportion of IPC time for both RNs and RTs (25.74% and 18.48%); alternatively, the active listening enabler utilized the highest proportion of MD IPC time (9.69%). Total time spent in behaviors like approach, invitation and validation represent the lowest proportion of IPC time across all the clinician roles, however the average time spent on each instance of these respective enablers was also considerably less with each lasting 7.30, 3.12, and 3.32 seconds per instance, on average. Send page was only observed by RNs and participating in this enabler used up approximately 4% of their total IPC time. Only RTs participated in verbal accessibility and it utilized less than 1% of their total IPC time.

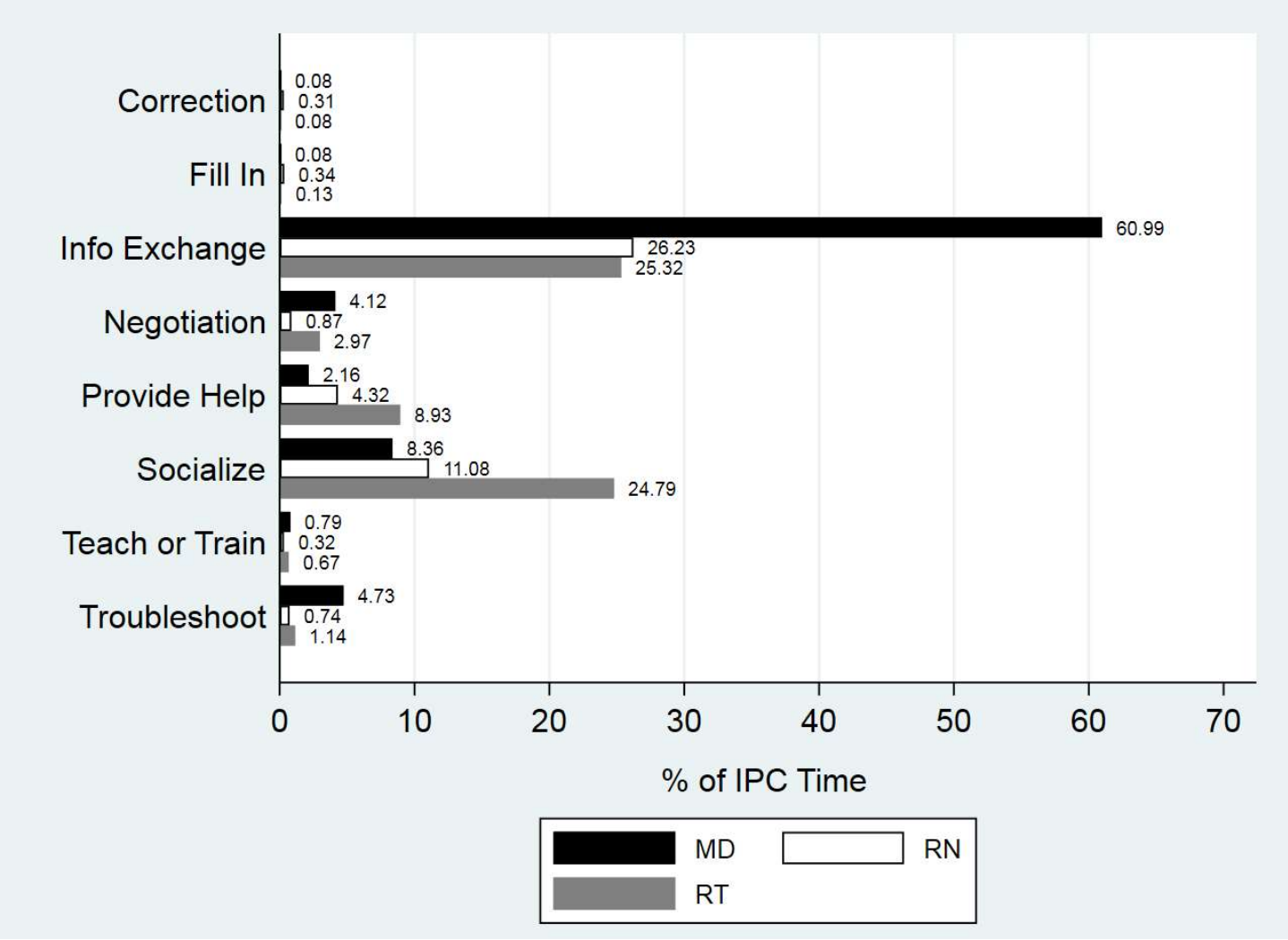
Figure 11 *Percent Distribution for Time Spent in Enablers by Clinician Role (n=176.83 total time (in mins) for enablers; n= 8.23 mins for MDs, n=81.45 mins for RNs, n= 87.15 mins for RTS)*



Note: Percentages based on total IPC time within each clinician role

Figure 12 displays the proportion of IPC time spent in the individual collaborative activities by clinician role. The percentages displayed are calculated by dividing the total time spent in each collaborative activity by the total time spent in IPC by role. The MDs spent approximately 61% of their IPC time in information exchange compared to RNs and RTs who both spent closer to 25% of their IPC time in this activity. Similar to the frequency data, the collaborative activity that comprises the second highest proportion of IPC time across the different clinician roles is socializing. Proportion of IPC time spent on providing help follows for the RNs and RTs, utilizing 4.32% and 8.93% of total IPC time, respectively. For the MDs, however, time spent in troubleshooting and negotiation followed socializing with each comprising approximately 4-5% of total IPC time. Thus, even though negotiation and troubleshooting occurred less frequently than providing help for MDs, these activities used more time among IPC behaviors for the MDs.

Figure 12 *Percent Distribution for Time Spent in CAs by Clinician Role (n= 255.37 total time (in mins) for CAs; n= 35.82 mins for MDs, n=64.52 mins for RNs, n= 155.03 mins for RTS)*



Note: Percentages based on total IPC time within each clinician role

Other Clinicians Involved and Location of IPC Behaviors

Table 25 and Table 26 present additional descriptive data collected on IPC via the time-motion tool. Table 25 describes how the different clinician roles (i.e. MD, RN, and RT) engaged in the IPC process with other clinicians. For the MDs, over half (53.54%) of IPC behaviors were observed with more than one clinician role, 35.35% of IPC behaviors were observed with RNs only and 6.06% of IPC behaviors were observed with RTs only. For RNs, approximately 43% of IPC behaviors were observed with more than one clinician role, 23.35% of IPC behaviors were observed with RTs only and 19.38% of IPC behaviors were observed with Residents/Interns only. Only 3.08% of RN IPC behaviors were observed with the Fellow MDs exclusively. Lastly, among the RT observations, most IPC behaviors were observed with RNs only, representing 64.73% of total RT IPC behaviors. 25.52% of RT IPC behaviors were observed with more than one clinician role and 1.45% of RT IPC behaviors were with observed with the Fellow MDs only. Examples of the Fellow, RN, and RT engaging in the IPC process together were not frequently observed (2.53 % of MD IPC behaviors, 0.44% of RN IPC behaviors, 0.83% of RT IPC behaviors).

Table 25

Frequency of Individual/ Groups of Clinicians Engaged in the IPC Process (n=907 total IPC behaviors; n=198 for MDs, n=227 for RNs, n=482 for RTs)

Clinician Roles	**MD (n (%))**	**RN (n (%))**	**RT (n (%))**
Fellow	0 (0.00%)	7 (3.08%)	7 (1.45%)
Attending	0 (0.00%)	10 (4.41%)	10 (2.07%)
Resident and/or Intern	0 (0.00%)	44 (19.38%)	15 (3.11%)
RN	70 (35.35%)	5 (2.20%)	312 (64.73%)
RT	12 (6.06%)	53 (23.35%)	6 (1.24%)
Other	5 (2.53%)	10 (4.41%)	5 (1.04%)
Fellow, RN, RT Triad	5 (2.53%)	1 (0.44%)	4 (0.83%)
More than one clinician role involved	106 (53.54%)	97 (42.73%)	123 (25.52%)

Note: Percentages based on total IPC behaviors observed within each clinician role

Table 26 describes the locations in the ICU unit where the observed IPC behaviors took place. Across all observations, approximately 82% of IPC behaviors were observed in the hallway or patient room. The remaining observed IPC behaviors occurred at the nursing station or in the unit break room.

Table 26

Frequency of Locations for IPC behaviors across all Observations (n=907 IPC behaviors)

Location	**N (%)**
Break Room	10 (1.10%)
Hallway	391(43.11%)
Nursing Station	152(16.76%)
Patient Room	354 (39.03%)

Observability of IPC Behaviors

Table 27 displays the total number of days each IPC behavior was observed at least once across all the observations. IPC behaviors that were observed on less than 50% of the observation days (i.e. <9 days) include: Intraprofessional Consults, Reflexive Questioning, Sending Pages, Verbal Accessibility, Correction, Fill in the Gap, Teaching/training and Troubleshooting. In contrast, ten IPC behaviors were observed on 50% or more of the observation days and include: Active listening, Approach, Coordinate Work, Invitation, Nonverbal accessibility, Validation, Information exchange, Negotiation, Provide help, and Socializing.

Table 27

Observability Across Observation Days (n=18 observation days)

IPC Behaviors	**Total Days Observed (n (%))**
Active Listening	14 (77.78%)
Approach	13 (72.22%)
Coordinate work	11 (61.11%)
Intraprofessional Consult	6 (33.33%)
Invitation	11 (61.11%)
Nonverbal Accessibility	11 (61.11%)
Reflexive Questioning	0 (0.00%)
Send Page	4 (22.22%)
Validation	15 (83.33%)
Verbal Accessibility	3 (16.67%)
Correction	6 (33.33%)
Fill in the Gap	6 (33.33%)
Info Exchange	18 (100.00%)
Negotiation	9 (50.00%)
Provide help	13 (72.22%)
Socialize	17 (94.44%)
Teach	7 (38.89%)
Troubleshoot	5 (27.78%)

Review of Data Collection Approach

After each observation session, observers were required to complete a post-data collection survey in which they provided a free text response describing any positives or negatives they experienced while collecting data. Table 28 and Table 29 summarize the strengths and challenges identified by the observers. Potential considerations when interpreting the data and items to address in future work are also presented.

Table 28

Strengths Identified during Data Collection

Strength	**Description**	**Implications for Data**	**Potential Adjustments for future Data Collection**
Clinician willingness to participate	Clinicians agreeing to participate for the entirety of the observation period.	High "response" rate	Supportive evidence for recruiting more clinicians from multiple sites
Clinicians providing contextual information	Clinicians talking aloud regarding who they were talking to or what they were doing.	Supports accurate data recording	Include as part of future protocol
Duration of individual observations	Not exceeding four hours of continuous data collection.	Increases accuracy of data since longer observations can be more cognitively taxing	Consider doing more observations of shorter duration
Adherence to proposed data collection process	Projected observations completed and target sample size achieved.	Feasible to time-sample data over nine weeks	Adjust or tailor data collection plan according to RN, RT, MD scheduling patterns in each site

Table 29

Challenges Encountered during Data Collection

Challenge	**Description**	**Implications for Data**	**Potential Adjustments for future Data Collection**
Space constraints	Maintaining a close proximity to clinician was difficult when there was a greater number of personnel on rounds or when clinician closed curtain for patient privacy.	Missed IPC behaviors	Additional training for observers, consider remotely monitoring clinician interactions
Minimizing distractions	On days when unit seemed particularly busy (crowded, loud) maintaining focus was more difficult.	Missed IPC Behaviors	Collect contextual data
Urgent clinical situations	During intense clinical situations, such as intubation and running a code, observer maintained a greater distance to not interfere with patient conduct of care.	Missed IPC Behaviors	Consider training and expanding IRB to allow observers to enter patient rooms and record urgent clinical situations when possible
Coupled/blended activities	During some encounters, observer perceived the clinician as quickly transitioning back and forth between collaborative activities (example of informational exchange and socializing) which made it difficult to capture the individual behaviors.	Missed IPC Behaviors	Grouping activities; Ability to pause or select multiple activities at once within one entry on application
Identifying exact Start Time	Determining the appropriate start time was not always clear to observer.	Missed time for IPC Behaviors	Additional training
Prematurely stopping timer	Determining the end of an encounter was not always clear to observer.	Missed time for IPC Behaviors	Additional training

Usability of tool	Functions of tool need to be refined to facilitate ease and accuracy of data collection.	Inaccurate data	-Back option -Double-check feature before saving an entry -Option for free text -Reordering layout -Disabling components to reduce errors (i.e. not letting timer 2 run while timer 1 is running)

Summary

In summary, this chapter presents the results from Aim 1, develop a task list for the process of IPC in the care of mechanically ventilated patients, and Aim 2, test the feasibility of using time-motion methods to measure the process of IPC in the care of mechanically ventilated patients. The final task list includes ten enablers and eight collaborative activities. All enablers and collaborative activities were observed or described by clinicians in both site 1 and 2; furthermore, all IPC behaviors were validated by at least one clinician participating in the member-checking interviews. The final task list was incorporated into the time-motion tool used to collect data in Aim 2. Observers successfully completed 18 days of data collection with 18 different clinicians over a nine-week period. The time-motion data indicates wide variation in the frequency and duration in which different clinician roles engage in the different enablers and collaborative activities. In addition, not all enablers and collaborative activities were observed every day of the data collection or with every clinician role. Due to the challenges identified in the current data collection approach, IPC behaviors may have been missed. Clinician willingness to participate in the observations suggests sample size and hours of observation can be scaled up in future work. Moderate refinements to the tool and data collection approach are recommended to increase access to pertinent observational data that can be used to quantify the process of IPC in the care of critically ill adults.

Chapter 5: Discussion

The purpose of this study was to develop a task list for the process of interprofessional collaboration and test the feasibility of using time-motion methods to quantify the process of interprofessional collaboration in the care of mechanically ventilated patients. The developed task list includes 18 specific behaviors embedded in clinician workflow that demonstrate participation in the IPC process; the final task list is the first comprehensive list of behaviors that both enable and indicate engagement in the IPC process. Time-motion data was collected over 61 hours in a single ICU. Results from this study suggest time-motion methods are a feasible approach to measure the process of IPC and data collected using this approach can reveal distinct patterns in the IPC process. This chapter begins with a discussion on the principal findings from aim 1 and aim 2 followed by the implications of this work, considerations for future research, limitations in the current study, and a conclusion.

Principal Findings

Aim 1

Aim 1: Task List for the Process of Interprofessional Collaboration

In this study, we identified 10 enablers to collaborative activities using qualitative data previously collected in two medical ICUs. Most of the enablers to collaborative activities were closely related to other facilitators to IPC found in other qualitative work. For example, in interviews with ICU clinicians, being accessible and approachable were both identified as facilitators to clinician engagement in IPC (Costa et al., 2014; Baggs & Schmitt, 1997). We

found verbal and nonverbal behaviors that resonate with these concepts. Furthermore, other work also describes coordinating time as beneficial for IPC in the ICU (Hawryluck et al., 2002; Bjurling-Sjoberg et al., 2017; Goldman et al., 2018) which we similarly capture in the coordinate work enabler in the current study. Information technology has been classified as both a facilitator and barrier to IPC (Costa et al., 2014; DeKeyser-Ganz et al., 2016). In the data we analyzed, clinicians tended to use technology (i.e. send pages or call) to initiate collaboration when clinicians were not available in-person. In some instances, the send page/call behavior was used as a secondary enabler following the attempted use of another enabler (i.e. approach); this may suggest that the send page/call enabler is not the preferred method for enabling collaboration by some clinicians. Interestingly, instances of the send page/call enabler were more prevalent in the site 2 data. This unit was larger in size and all clinicians carried personal portable phones which possibly suggests that unit design and available technology may play a role in the IPC process.

Other studies have found that interpersonal factors also serve as facilitators to IPC. In two separate interview studies with ICU clinicians, participants perceived that value for each other's knowledge and expertise enhanced collaboration in practice (Costa et al., 2014; Goldman et al., 2018). In our analysis, we found invitation to be a simple but effective way clinicians enabled other clinicians to offer their perspective. Validation appeared to be a separate behavior that clinicians used to substantiate other's contributions and encourage further collaboration. In addition to value, mutual respect is also considered to be an antecedent to meaningful collaboration (Kendall-Gallagher et al., 2016). Behaviors from our task list that clinicians may use to convey respect towards their colleagues include active listening, which is identified as a facilitator to collaboration in other work (Baggs & Schmitt, 1997), and reflexive questioning. The later behavior, reflexive questioning, has not been explicitly identified as a facilitator to IPC;

however, in another ethnographic study examining interprofessional work in the ICU, the investigators similarly found that use of "subtle cues" opposed to "overt confrontation" supported meaningful shared decision-making between ICU clinicians (Xyrichis et al., 2017).

Intraprofessional consultation is a unique enabler that has not been previously discussed in the IPC literature. Previous work has reported, however, that clinicians appear to spend more time in intraprofessional interactions than interprofessional interactions (Alexanian et al., 2015; Reeves et al., 2015). But in our analysis, we found that intraprofessional and interprofessional work were not always mutually exclusive. Indeed, in some instances, clinicians consulted with their fellow professional colleagues to clarify their thought process before initiating a collaborative activity with another professional. We perceived intraprofessional consults as enabling interprofessional collaboration in these instances and included the behavior as an enabler in the IPC task list.

We identified eight collaborative activities in our analysis; similar to the enablers, many of these behaviors relate to other concepts discussed in the interprofessional collaboration literature. Communication, for example, is frequently identified as a key component of the collaborative process (Reeves et al., 2010; Costa et al., 2014). Indeed, most observable collaborative activities in the observation and shadowing data centered around communication and clinicians frequently discussed the importance of communication when reflecting on the qualities of effective collaboration and teamwork in the interview data. Information exchange appeared to be the most common collaborative activity used by clinicians. In a separate study exploring collaborative decision-making in the ICU, Dekeyser-Ganz and colleagues (2016) similarly defined the concept of information exchange as clinicians relaying pertinent information and updates to other clinicians; yet, the investigators described it as only a one-way

flow of information. We, however, observed both one-way and two-way instances of information exchange.

Correction and fill in the gap are unique communication encounters that clinicians appeared to use, in addition to information exchange, to support a shared understanding about the patient's condition with fellow clinicians. Similar to correction, error-checking and feedback have been identified as critical behaviors in high-functioning teams (Rosen et al., 2018). Filling in the gap has not been previously discussed as an independent concept, however, the ability to anticipate other's needs and react appropriately is theorized to be another important skill in high-functioning teams (Boltey et al., 2019; DeChurch & Mesmer-Magnus, 2010). In the instance of fill in the gap, clinicians implicitly recognized a gap in communication and responded accordingly by communicating the relevant information to their colleagues.

Building on the concept of open communication, shared decision-making is another component of collaboration discussed in prior work that relates to the negotiation and troubleshooting behaviors identified on our task list (D'Amour et al., 2005). We found clinicians participated in negotiation before implementing a change in patient care. Typically, one clinician communicated a specific request to another and then the clinicians engaged in a back and forth dialogue until they determined an appropriate course of action. This conceptualization has surfaced in other work. Lingard and colleagues (2004), for example, interviewed groups of ICU clinicians and found that collaboration in the ICU could be described as comparable to trading because clinicians are perceived as undergoing frequent negotiations with other providers as they work together to deliver care. In comparison to negotiation, troubleshooting related to specific instances in which clinicians dialogued to solve a problem. Instead of one clinician trying to get buy-in from other clinicians on a decision, two clinicians worked together to propose potential

solutions to manage an unexpected event. In previous studies, Reeves and others similarly identified distinct differences in the urgency and intensity of interprofessional interactions when clinicians were working together to resolve a crisis compared to when they were working together to deliver routine care (Piquette et al., 2009; Reeves et al., 2015; Xyrichis et al., 2017). And so, our findings are consistent with other IPC work and suggest that different types of shared decision-making behaviors can play a unique role within the greater collaborative process.

In addition to activities that center exclusively around communication, supportive activities like interprofessional learning opportunities and sharing responsibilities are also discussed as valuable components of collaboration (Baggs & Schmitt, 1997, Goldman et al., 2018; Costa et al., 2014; D'Amour et al., 2005; Kendall-Gallagher et al., 2016). The teaching/train and providing help activities in our task list are analogous to these previously discussed concepts. In the current literature base for IPC in the ICU, the role of socializing in interprofessional collaboration is largely unexplored. Reeves and colleagues (2010) introduce humor, a component of socializing, as a team process in their conceptual model for interprofessional teamwork, however the value of socializing in interprofessional work has yet to be examined. Instances of socializing were often described in the qualitative data and in the member-checking interviews, clinicians confirmed that they perceived it to be an important component of collaboration. We gathered that instances of socializing may be a way to gauge the degree of collegiality between clinicians and so we included it as a collaborative activity in the task list.

Along with the qualitative literature, there are similarities between behaviors identified on the task list and behaviors evaluated in previously developed surveys and observational rating

tools for collaboration and teamwork in the ICU. For example, items related to quality of communication, shared decision-making, cooperative problem-solving, and perceived support are all identified in the most commonly used surveys to measure collaboration and teamwork in the ICU (Baggs, 1994; Shortell et al., 1991; Sexton et al., 2006). Existing observational rating tools for teamwork in the ICU also report rating the following behaviors: communication of information, error correction and clarification, asking for and offering assistance, managing disagreements, and contingency planning (Frengley et al., 2011; Dietz et al., 2018) which are similarly related to the collaborative activities: information exchange, correction, providing help, and negotiation. In these other observational rating tools designed for teamwork evaluation in the ICU, additional behaviors related to delegation and leadership are included. Collaboration is conceptualized as a nonhierarchical type of interprofessional work (Henneman et al., 1995; D' Amour et al., 2005) and so it stands to reason that these types of behaviors are not identified as critical components of the collaborative process.

In summary, many of the enablers and collaborative activities identified in the task list are consistent with previously described themes in the IPC literature which validates our findings. Though other work has discussed similar concepts related to interprofessional collaboration, the developed task list is the first compilation of those behaviors that both enable and demonstrate IPC. By identifying both enablers to collaborative activities and actual collaborative activities, the findings in this study reinforce the conceptualization of IPC as a process. Other, not previously discussed IPC behaviors, such as intraprofessional consultation as an enabler and socializing as a collaborative activity, are also identified which demonstrates the benefit of conducting member-checking interviews with clinicians since this approach resulted in a broader conceptualization of what constitutes IPC in practice. Overall, the final task list is a

unique contribution that provides a more comprehensive understanding of how ICU clinicians participate in the IPC process.

Aim 2

Aim 2: Test the feasibility of using time-motion methods to measure IPC

This study aimed to test the feasibility of using time-motion methods to measure the process of IPC in the care of critically ill adults. After evaluating the process, there is evidence supporting the feasibility of this approach. First, I was able to train two non-clinician research assistants with no prior experience in using observational tools to use the time-motion tool, as evidenced by our acceptable inter-rater reliability. This suggests that using the tool does not require a unique clinical perspective. Further, there is a broad population of observers who could be trained to use the tool which supports the future scalability of the study methods. In addition, we were able to recruit our target sample size with adequate variability in a relatively short timeframe in the current study which also supports the feasibility of using time-motion methods to quantify the IPC process in practice. As discussed in the results section, we extended the weeks of data collection to achieve adequate variation in the respiratory therapist sample. Only one previous study in the time-motion literature recruited respiratory therapists to participate in observations (Ballermann et al., 2011) and so, prior to this study, there was limited data on any recruitment challenges pertaining to this population of care providers. Overall, respiratory therapists represent a lower percentage of total healthcare providers, in comparison to nurses and physicians, (Bureau of Labor Statistics, 2019) and so they may be a more difficult population to access. Further, the specific unit from where we were recruiting respiratory therapists was within an academic medical center where there was a high percentage of respiratory therapist students. Given the nature of our data collection approach, it would have been infeasible to have a student

and an observer from this study following the same respiratory therapist; this added complexity to our recruitment strategy. However, respiratory therapists represent a critical member of the ICU patient care team. Thus, prioritizing data collection approaches that increase access to a varied sample of clinician participants, even if this leads to extending the overall duration of data collection, may be necessary to comprehensively evaluate the IPC process.

Since time-motion methods are designed to collect data on observable tasks, the degree of observability for the behaviors that demonstrate participation in IPC also speaks to the feasibility of using this approach to quantify the IPC process. Ten behaviors, which constitutes a majority of the behaviors on the task list, were consistently observed (i.e. observed at least once on 9 or more observation days). The remaining eight behaviors were observed on less than 50% of the observation days which may suggest low observability for these specific behaviors; these behaviors include both enablers and collaborative activities and only one behavior was never observed—reflexive questioning. The observability criterion (i.e. 50% threshold) was derived from the observational rating tool literature (Thomas et al., 2004; Hull et al., 2011; Flowerdew at el., 2012). Fifty percent is an arbitrary cutoff point and may not be an appropriate metric to use to determine the absolute feasibility or infeasibility of using a time-motion approach to measure IPC. Moreover, it appears that some of the challenges we encountered during the data collection process may have resulted in missed IPC behaviors which could explain why some of the behaviors are perceived as "less observable." The process can be refined, however, in future work to mitigate the identified challenges.

For example, observers found that due to space constraints, they were sometimes too far away from clinicians to discern the details of their conversations which made it difficult to determine if they were or were not engaging in a collaborative activity. This was further

exacerbated during urgent clinical situations like a rapid intubation or code situation. There are, however, two possible solutions to addressing the difficulties in hearing clinician interactions. First, additional training may be needed to prepare observers to navigate these particular situations. The goal of the video training was to ensure observers could accurately and reliably identify behaviors from the IPC task list, however it may not have adequately trained observers to consistently identify the respective behaviors within the more fast-paced, chaotic clinical environment. Observer training could be refined to include an additional clinical component during which observers-in-training practice using the tool with a trained expert while in the clinical environment. Second, it is possible that existing technologies could be used to remotely monitor clinician IPC interactions. Sensor-based measurements, such as Radio-frequency identification (RFID) tags, have been used in acute healthcare settings to quantify clinician interactions broadly (Isella et al., 2011; Kannampallil et al., 2011). These studies use individual sensor tags to determine how frequently clinicians come in close "contact" with one another over an average shift (Rosen, Dietz, Yang, Priebe, & Pronovost, 2015). In other industries, this technology has been adapted to include voice sensors as well (Olguin et al., 2008). If implemented in the clinical setting, the data collected via this technology could be retrospectively analyzed to determine the duration and frequency of specific types of IPC behaviors. Due to the uncontrolled clinical environment and a responsibility to not interfere with clinician workflow while collecting data, spatial limitations may not be fully addressable in future work; however, using multiple methods (i.e. sensor-based measures and time-motion methods) could be a novel solution.

In some instances, clinicians were perceived as engaging in activities concurrently which made it difficult for the observer to capture individual behaviors; this could have resulted in a

lower frequency count for certain IPC behaviors. As our tool was developed, observers could not select more than one behavior per entry. Since this was a feasibility study, we had no baseline data for how frequently clinicians participated in more than one IPC behavior at a time and so we designed the first version of the tool to capture IPC behaviors as distinct occurrences. Other time-motion tools have been developed, however, to allow observers to record instances of multi-tasking (i.e. participating in two tasks simultaneously) which could be an appropriate solution based on the observers' experiences in the current study (Westbrook & Ampt, 2009). Furthermore, it may be of interest to consider collecting the frequency and duration of collaborative activities or enablers more broadly instead of differentiating the specific types of behaviors. In the training, observers had a higher percentage agreement for identifying behaviors appropriately as enablers or collaborative activities compared to the specific type which suggests this approach may be more feasible. With these data, we would still be able to quantify the percentage of time clinicians spend engaged in the collaborative process overall however, we would not be able to differentiate by types of IPC behaviors. Creating an option to either document multi-tasking or broadening to allow documentation of a collaborative activity or enabler without specifying the type could address the limitation of being unable to capture multiple behaviors per entry.

In summary, time-motion methods are a feasible approach to quantify the IPC process, however changes need to be implemented in future work to ensure the data collected via this approach is an accurate representation of the IPC process in practice. Since this was a feasibility study, it did not aim to test for clinically meaningful differences in IPC engagement; however, the patterns that emerge from these preliminary data are hypothesis-generating.

This is the first study to use time-motion methods to quantify the frequency at which ICU clinicians engage in different IPC behaviors during their normal workflow. We observed 907 instances of IPC behaviors; over half of the total observed IPC behaviors were demonstrated by the RTs (n=482; 53%), followed by the RNs (n=227, 25%) and MDs (n=198; 22%). Across all roles, collaborative activities were observed more frequently than enablers to collaborative activities. Interestingly, almost half of all observed IPC behaviors were classified as information exchange—a collaborative activity (~45% of IPC process for individual roles and overall). There appeared to be more variation in the different types of enablers each clinician role used. Additionally, some enablers including sending pages, verbal accessibility, and intraprofessional consults were not used by all clinician roles during the observations.

The variation in the frequency of IPC behaviors by role may be influenced by different clinical and contextual factors. We found that RTs engaged in IPC behaviors more frequently than MDs and RNs in our observational data. RTs were also involved in the care of a higher volume of mechanically ventilated patients across all the observations (25 MV patients compared to 23 for MDs, and 6 for RNs). Thus, being involved in the care of more patients may inherently increase the clinician's tendency to participate in the collaborative process. For example, an RT who is involved in the care of four mechanically ventilated patients on a typical shift may engage in four separate information exchange activities with four different RNs to communicate the status of patients' spontaneous breathing trials compared to a RN caring for one mechanically ventilated patient during a shift who may engage in one information exchange activity with a RT about the status of a patient's awakening trial. However, the relationship between number of mechanically ventilated patients cared for and the frequency of IPC behaviors does not appear to hold when considering the time-motion data collected during the MD observations. Like the

RTs, the median number of MV patients cared for by MD participants per observation period was 4 and the overall count of MV patients cared for by MDs across all observations was just shy of the overall count for RTs (23 vs. 25). Despite being involved in the care of a higher volume of MV patients, compared to RNs, the total count of IPC behaviors was lowest for MDs. A potential explanation may be related to the timing of the observations which were conducted between 0700 and 1230 during morning rounds. In this unit, we observed variable participation in rounds by allied health professionals including respiratory therapists and nurses. Furthermore, as a teaching hospital, rounds were often dedicated to medical training and professional development. Thus, we may have observed less IPC behaviors by MDs because we conducted the observations during a time when MDs may have been predisposed to participate in fewer interprofessional interactions.

It is also interesting to consider how different clinical and contextual factors may have influenced the distribution of specific types of collaborative activities and enablers. The high frequency of information exchange, compared to other IPC behaviors, may also be the result of conducting the observations in concurrence with rounds. Interprofessional rounds are conceptualized as a formal opportunity for clinicians to provide updates or share new information on the patient's status or plan of care (Rose, 2011). Within this context, observers may have been exposed to more instances of information exchange. Furthermore, there may be underlying relationships between the use of certain activities. For example, we may hypothesize an inverse relationship between the rate of information exchange and the rates of correction or fill in the gap. Specifically, since the frequency of information exchange was so high in our data, one could theorize that clinicians consistently had access to timely and accurate information, thus they did not have to use the correction or fill in the gap behaviors as frequently. Socializing was

also among the most frequently observed collaborative activities. It stands to reason that if socializing supports a collegial environment, frequent engagement in socializing may increase overall engagement in IPC. Thus, instead of being directly related to one collaborative activity or enabler, socializing may be interrelated with many IPC behaviors. Exploring these types of relationships in future work could help explain why in practice different patterns emerge in the IPC process.

Relationships may also exist between the different types of enablers clinicians use to facilitate collaboration. For example, all clinician roles were observed using in-person enablers like active listening, approach, invitation, nonverbal accessibility, and validation more frequently than non in-person enablers, like sending pages. One interpretation could be that clinician preference for face-to-face collaborative encounters conditions them to use certain types of enablers more frequently. Despite the identified pattern, the relative frequencies of the specific types of enablers did differ by clinician role. In addition, unlike the collaborative activities, not all clinicians roles were observed using every type of enabler. To reiterate, only RTs engaged in verbal accessibility, only RNs engaged in sending pages and only RTS and RNs used intraprofessional consults in the observational data. In the parent study data, both MDs and RNs described using verbal accessibility and it was validated as an enabler in the MD interview; this enabling behavior may thus still be used by MDs and RNs even though we did not observe any instances during our observations. Similarly, in the qualitative data, RTs and MDs were observed using the send page or call enabler which suggests this enabler may also not be exclusive to RNs. In comparison, examples of intraprofessional consult were only identified with RNs and RTs in the qualitative data; this specific enabler was also validated in the RT interview. Based on this finding, it is possible that the intraprofessional consult enabler is a behavior specifically used by

RNs and RTs. Interprofessional collaboration is conceptualized as a nonhierarchical type of interprofessional work (Henneman et al., 1995; D'Amour et al., 2005), however clinicians perceive that traditional power dynamics can still surface and influence the nature of collaborative encounters (Alexanian et al., 2015). This may explain why nurses and respiratory therapists are more likely to engage in intraprofessional consults during which they confer with fellow colleagues before contacting a member from the medical team. The overall count of this enabler, however, is relatively low for both RNs and RTs which suggests in most instances clinicians from this particular unit feel comfortable engaging in direct interprofessional interactions. Overall, the tendency for clinician groups to use certain types of enablers more or less frequently is a unique finding. It may suggest that professional training and socialization can influence the types of IPC behaviors clinicians use (Hall, 2005) and that any interventions designed to facilitate collaboration may need to take into consideration the variations in enabler use across different clinician roles.

The frequency data is useful for understanding how clinicians use interprofessional collaboration in practice; the duration data, however, quantifies the impact of engaging in interprofessional collaboration on clinician workflow. We calculated mean time spent on each IPC behavior as well as overall time spent on IPC behaviors. All instances of IPC lasted less than 2 minutes on average, which provides quantitative support for the episodic nature of IPC in practice (Alexanian et al., 2015; Reeves et al., 2015; Reeves et al., 2018). We found that overall time spent in the collaborative process appeared to differ by clinician role. In our data, MDs spent approximately 4% of the observation time in the collaborative process compared to 12% for RNs and close to 20% for RTs. In aggregate, clinicians were observed spending less time in enablers (41% of IPC time) compared to collaborative activities (59% of IPC time), which makes

sense considering the overall frequency of enablers was considerably less than collaborative activities. However, when comparing clinician roles, nurses actually spent more time in enablers (56% of IPC time) compared to collaborative activities (44% of IPC time). Similar to the frequency data, notable differences in how clinicians spent time in specific enablers and collaborative activities were also identified. For example, MDs spent approximately 61% of their IPC time in information exchange compared to 25% and 26% of RT and RN IPC time, respectively. An interesting finding from the duration data is that some activities that occurred less frequently actually comprised a larger proportion of IPC time. For example, among the MD IPC behaviors, troubleshooting and negotiation represented less than 3% of total IPC behaviors. However, together troubleshooting and negotiation utilized 9% of total IPC time for MDs. Together these findings suggest that it is important to consider both the frequency and duration of IPC behaviors, as well as clinician roles, when describing IPC quantity.

The variation in overall time spent in the collaborative process by clinician role is a unique finding. No studies to data have quantified time spent in interprofessional collaboration specifically, however, it is interesting to consider how time spent in the IPC process among the clinicians in our sample compares to average time spent in clinician interactions more broadly as described in other time-motion studies conducted in the ICU setting. Ballermann and colleagues (2011), for example, found that ICU nurses, respiratory therapists, and physicians spend 38%, 54%, and 73% of their work time, respectively, in the task of professional communication defined as "any work-related discussion with another staff member." The interprofessional or non-interprofessional nature of these interactions, however, was unknown. Douglas et al. (2013) and Carayon et al. (2015) addressed some of this ambiguity in the separate time-motion studies they conducted aiming to quantify patterns in ICU nurse and physician workflow. The

investigators used a different time-motion tool than Ballerman and colleagues (2011); it included a task for "care coordination" which was further divided into specific types of staff conversations including conversations with unit physicians, conversations with nurses, and conversations with other ICU staff (includes unit pharmacist, RTs, unit clerk). Douglas and colleagues (2013) found that ICU nurses spent approximately 5% of their work time in interprofessional conversations (i.e. combination of time spent conversing with unit physicians and time spent conversing with other ICU staff) which was less than ICU residents and attendings who Carayon and colleagues (2015) found spent approximately 6% of work their time in interprofessional conversations (i.e. combination of time spent conversing with nurses and time spent conversing with other staff).

The estimates presented in the current study for the percentage of time ICU clinicians spend in the IPC process and the estimates reported by Douglas et al. (2013) and Carayon et al. (2015) for the percentage of time ICU nurses and physicians spend in interprofessional conversations are considerably less than the estimates Ballerman and colleagues (2011) present for the proportion of time ICU clinicians spend in professional communication more broadly. This suggests that focusing exclusively on interprofessional interactions can yield different insights into how clinicians spend time interacting with other clinicians within their normal workflow. No data was collected on time spent in enablers to clinician interactions in these prior time-motion studies. It is interesting to consider that Douglas and colleagues (2013) estimated ICU nurses spend about 5% of their time in interprofessional conversations. In the current study, nurses spent approximately 12% of the observation time in IPC, but they spent a larger proportion of their time in enablers compared to collaborative activities. Due to differences in total hours of observation, ICU settings, and times of day sampled between these two studies, the

results are not directly comparable. However, this does potentially stress the importance of quantifying time spent in enablers to collaboration in addition to quantifying time spent in communication exclusively since, in certain instances, engaging in enablers can be more time-consuming but may be more beneficial.

In summary, this is the first time-motion study to quantify how clinicians engage in the process of interprofessional collaboration exclusively. The wide variation in the duration and frequency at which different clinician roles engaged in the different enablers and collaborative activities seems consistent with the conceptualization of IPC as a dynamic process. Many different factors including professional characteristics, clinician responsibilities, and the timing of observations may explain the patterns we observed in this study. Testing the reproducibility of these results in future work can provide greater clarity on how ICU clinicians use collaboration in practice.

Implications

The main purpose of this feasibility study was to test the application of time-motion methods to measure the process of interprofessional collaboration. There is evidence supporting the feasibility of using this approach and so, future studies should consider increasing the use of time-motion methods to quantify the process of IPC in the delivery of complex care practices in the ICU with larger sample sizes and/or different ICUs. Furthermore, analyses of the time-motion data collected in this feasibility study can also serve as preliminary findings to inform the field of IPC research. For instance, this is the first study, to my knowledge, that provides quantitative evidence supporting IPC's conceptualization as an episodic process. This finding underscores the limitations of other measurement approaches, including surveys and previously used observational rating tools, which fail to capture the dynamic nature of IPC. Furthermore,

the results of this study suggest that each clinician role may engage in the collaborative process differently; that is, clinicians may use different combinations of enablers and collaborative activities depending on their professional roles or perceived patient needs. These findings imply there is not a one-size-fits-all approach to interprofessional collaboration; this may have implications for future practice interventions. To date, interventions designed to improve collaboration and teamwork in the ICU have focused on standardizing collaboration through policy changes such as instituting daily interprofessional rounds or by participating in team training initiatives adopted from other industries. There is no strong evidence supporting the effects of these approaches to collaboration and/or patient outcomes. Based on the results of this study, I hypothesize the nature of collaboration fluctuates based on both clinical context and clinician role. Therefore, instead of focusing exclusively on standardizing collaboration, it may be beneficial to focus future efforts on increasing clinician awareness of the different behaviors clinicians use to enable and engage in collaboration so that they can support each other's participation in the process and possibly, better align patient care needs with specific IPC behaviors.

Since this was a single site feasibility study, I was only able to compare differences in the distribution of IPC behaviors by clinician role, however it seems plausible that differences in the IPC process may also emerge when comparing different ICU units. Ultimately, variation in the IPC process may have implications for care delivery. Because prior work has failed to quantify the process of IPC, it is currently unknown if the quantity of IPC is correlated with better care. A "dose-response" could theoretically exist where a larger quantity of IPC exhibits a stronger effect on system, clinician, and patient outcomes until a critical threshold is met where additional IPC does not yield anymore net benefit. To test for this effect, data will need to be collected from

multiple sites to determine if different quantities of IPC, operationalized as a greater frequency and duration of IPC behaviors, are associated with improved clinical outcomes. If a larger quantity of IPC does result in better outcomes, care delivery may need to be reorganized to ensure clinicians can engage in the necessary amount of IPC behaviors to deliver safe care. One way this could potentially be achieved is by ensuring there is adequate staffing for all ICU clinicians. Different types of ICU staffing models currently exist; some adhere to an open ICU model whereas others are closed ICUs. In closed ICUs, clinicians may have more access to ICU physicians which could result in a higher quantity of IPC, though this has yet to be tested. Overall, implementing organizational interventions to support IPC more broadly may also be beneficial since the clinicians participating in IPC do not remain constant.

The results of this study also challenge previous conceptualizations of what constitutes IPC in practice. Interprofessional socializing has not been extensively discussed as a component of IPC yet it emerged as a type of IPC behavior that was frequently observed by all clinician roles in the current study. Trust, respect, and familiarity have been discussed as facilitators and attributes of IPC (Costa et al., 2014; Hughes et al., 2017); socializing may be a mechanism through which clinicians can humanize their fellow colleagues and develop strong working relationships. If more frequent socialization is associated with better IPC and outcomes, that can have implications for future interventions as well. There is limited evidence demonstrating a lasting effect for team training interventions exclusively, however incorporating team building opportunities, which focus on cultivating social relationships between colleagues, could be a unique approach to support collaboration in practice.

Considerations for Future Research

There were multiple approaches used in the current study that optimized our data collection methods. Using the iOS-based application to collect the time-motion data, opposed to paper and a stopwatch, streamlined the data collection process and expedited the analysis. After data collection, we identified potential changes to make to the tool to enhance its usability and functionality in future work. The research assistants described the application as intuitive to use; however slight modifications to the layout could be beneficial. Reordering the enablers and collaborative activities so they are in alphabetical order could reduce the time observers spend locating the appropriate behavior. The option to provide free text may also be useful in future iterations of the application. This could be used to provide additional information when the "other" option is selected among the clinician roles and location. Furthermore, one of the challenges that arose from data collection was that during particularly chaotic times in the unit, it was more difficult to capture behaviors. Having the ability to record contextual data within the application to describe different clinical scenarios could be a unique way to gather additional data to generate more insight into how different patterns unfold in the observational data. Error-checking features should also be embedded in the application to protect the validity of the data. In the current version, there is a "trash" function that allowed users to discard data they started entering but then decided not to save (i.e. determined an IPC behavior did not actually occur). There was no "back option" to allow users to make changes to or discard previous entries that may have been prematurely saved. An alternative approach could also be to have a double-check feature so that when an entry is saved, a pop-up box appears listing the data that is about to be saved so the user has the option to discard if an error is identified. Lastly, changing the function of the application so that more than one enabler or collaborative activity behavior can be selected

per entry may be beneficial to capture concurrent behaviors. The identified changes could increase data accuracy and should be implemented and tested in future work.

Based on the analyses of the substantive data collected in this feasibility study, I hypothesize that relationships may exist between certain IPC behaviors, but due to the limited quantity of data collected in this study, I cannot explicitly test for these relationships. One way we could test for these types of relationships in future work is by exploring the time-motion data with timestamps to determine if certain IPC behaviors regularly precede one another in practice, an analytical approach described in another time-motion study (Carayon et al., 2015). Anecdotally, certain patterns appeared to emerge while collecting the observational data in the current study. For example, an invitation enabler was often followed by an information exchange encounter. Being able to quantitatively define these types of relationships and the order of IPC behaviors could provide a more thorough understanding of the IPC process in practice which could assist with the development of future interventions to improve collaboration. For example, if several enablers were identified to precede the most common and effective collaborative activities, interventions could focus on fostering an environment that supports the use of such enablers to create opportunities for effective interprofessional collaboration in practice. Additionally, it may be beneficial to design future time-motion studies to collect data on the IPC process while observing more than one clinician role during the same timeframe. The timestamped data could then be analyzed to determine how frequently IPC behaviors are reciprocated, or not reciprocated, by each clinician role. For example, if collecting separate time-motion data on a RN and RT concurrently, it would be interesting to determine how frequently enablers initiated by a RN to a RT are succeeded by a RT engaging in a collaborative activity with the RN. If the rate at which enablers are observed but not reciprocated is relatively high,

this could potentially be interpreted as an inefficient use of the IPC process and may need to be addressed in future improvement efforts in a particular ICU unit. Overall, evaluating the timestamped data in future work could explain how different patterns in the IPC process emerge and how different IPC patterns can potentially impact care delivery.

To conduct these more intricate analyses, future studies will also need to collect more robust data on the collaborative process by conducting more observation hours with larger sample sizes across multiple sites. The timing of the observations in the current study may have influenced the patterns that emerged in the IPC process. In future work, more observational data will need to be collected over different times of the day to generate a more accurate approximation of the average time clinicians spend on different components of the collaborative process within their normal workflow. Collecting data from a larger sample of clinicians across different sites would also increase the generalizability of the results. With more robust data, future studies can test if variations in the IPC process are associated with ICU outcomes. It is still unknown in the current literature if a direct relationship between IPC and outcomes exists. In addition to applying a more accurate approach to measure the IPC process, future studies will need to use more rigorous study designs to test for these effects. Ideally, future studies will be designed to collect similar quantities of time-motion data from multiple ICU units with comparable organizational characteristics such as size, patient population served, teaching affiliation, staffing, and the implementation of certain unit policies such as the routine use, or not routine use, of daily interprofessional rounds. After controlling for these potentially confounding effects, the time-motion data can then be analyzed to determine if variation in IPC quantity exists and, subsequently, if a certain quantity of IPC is associated with better outcomes. Ultimately, the

results of these types of studies can fill the knowledge gap surrounding the effects of IPC on ICU outcomes.

Limitations

While this is one of the first studies to use time-motion methods to assess the process of interprofessional collaboration in the ICU, there are several noted limitations. Specifically, there are limitations due to potential biases, low generalizability and limited evidence for reproducibility. Beginning with potential biases, direct observation was used to collect the time-motion data. There is risk that due to the Hawthorne effect, clinicians may have changed their behavior while being observed. However, by conducting the observations over a longer period (i.e. 3 to 4 hours per observation session), the likelihood that clinicians could sustain changes in their behavior was greatly reduced. I conducted most of the observations sessions and I recognize that due to my professional training as a nurse, I may have a biased perspective. To reduce this bias, I assigned each RA to participate in at least two different clinician role observations and no observer, including myself, observed one role exclusively. There may be concern that by only focusing on the quantity, and not the quality, of IPC interactions, the results of this study may not yield a comprehensive understanding of IPC. However, one can infer that if the quality of IPC interactions is poor, clinicians would be less likely to engage in IPC which would result in a lower overall frequency and duration of IPC interactions. Thus, focusing on the quantity of IPC can reveal insights into the nature of IPC and is arguably more objective than evaluating the quality of IPC for which there is no gold standard evaluative tool at the moment. Lastly, time-motion studies only collect data on observable tasks in a process. In the task list, I was able to identify 18 different observable behaviors that demonstrate participation in IPC. In practice however, the observability was variable. This could suggest clinicians were not using

certain behaviors as frequently or that they were using other, potentially unobservable, mechanisms to engage in IPC. This cannot be parsed out with the current data; however, it should be evaluated in future work. Regarding generalizability, the data presented in this study was collected from a small sample of clinicians from a single ICU. Furthermore, only descriptive statistics were calculated. Thus, results of this study may not be generalizable to other clinicians. Since this was a feasibility study, I did not test for reproducibility. However, the results of this study suggest future work should attempt to replicate these methods in larger sample sizes and across multiple ICU units to see if different patterns in the IPC process occur.

Unique strengths are also identified in the current study. We used a rigorous qualitative approach to develop and validate the task list for the process of interprofessional collaboration. Using different sources of qualitative data (i.e. observations, shadowing and interviews) from two different sites and conducting member-checking interviews increases the validity of the reported results. Additionally, using two qualitative coders supports the reliability of our qualitative results (Mays & Pope, 1995). Despite the identified limitations, by equally distributing the number of participants, number of days, and hours of observation by clinician role for the time-motion data, I was able to directly compare the frequencies and durations of IPC behaviors by clinician role. The primary purpose of this feasibility study was to evaluate the application of time-motion methods to measure the IPC process. Since this approach was found to be feasible, the time-motion data collected in the current study can serve as preliminary findings for future work. Specifically, these data reveal that clinicians may participate in the collaborative process differently which has important implications for how we study interprofessional collaboration in future work.

Conclusion

In conclusion, this study aimed to address the measurement gap identified in the IPC literature by testing the use of time-motion methods to quantify the process of IPC in the care of critically ill adults. This study contributes a new task list for the process of interprofessional collaboration which is the first compilation of observable behaviors that clinicians use to both enable and participate in the IPC process. The results of the feasibility study suggest time-motion methods can be feasibly used to quantify the complex IPC process. Furthermore, using time-motion methods to quantify IPC can reveal distinct patterns in IPC utilization. The findings of the current study indicate variations in the frequency and durations at which ICU nurses, respiratory therapists, and physicians participate in different components of the IPC process which may have implications for future practice interventions. The scope of this project was acceptable for a feasibility study, however after evaluating the process, it appears that slight modifications to the time-motion tool, observer training, and time sampling approach could increase the validity of the results in future work. Future studies may then seek to identify what factors are associated with specific IPC patterns and, ultimately, if different IPC patterns are associated with better ICU system, clinician and patient outcomes.

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Appendices

APPENDIX A-1

Interview Guide for Interprofessional Teamwork Study (Parent Study)

Instructions to Begin the Interview:

1. Introduce myself (whoever is present)
2. Describe objective of the interview

The purpose of this study is to understand how the ICU team works together (or not) by hearing your in-depth stories of caring for different types of ICU patients. As part of this project we would like to ask you some questions related to patient care, team interactions and ICU family involvement.

This interview will be audio-recorded so that we have an accurate record of your thoughts. If, at any time, you feel that the questions are too sensitive, I would be happy to turn off the tape recorder during that portion of questioning. Once the interviews have been transcribed, the recording will be destroyed and the transcript will contain no identifying information. No one, except for the research team, will have access to the transcript.

We also wanted to mention that we will be giving a $20 gift certificate as a small token of our appreciation for your participation.

Do you have any questions before we begin?

1) Establish rapport:
    a. Can you tell me a little bit about how long you have worked in this ICU?
    b. In your role?
    c. Have you worked in other ICUs?

2) Can you tell me if there are other ICU clinicians that are integral to assisting you in your role in this ICU?
    a. If so, who are they?
    b. Are families included as part of the ICU team?

3) I'd like to focus our discussion around care for different types of ICU patients:
    a. Mechanically ventilated patients
    b. Chronically ill patients
    c. Acutely ill/multi-organ failure patients
    d. End-of-life patients
    e. When delivering ABCDE to your patient

    Can you describe to me a story of caring for a patient from each of these categories? Can you explain in your own words how the team cared for one of these patients?

    f. Probe regarding:
        i. Setting
            1. Where was the patient's room?
            2. Had you cared for this patient before before?
            3. Was family present? Was the family involved in care at all – how so?
            4. Was the patient communicative? Involved?
        ii. Atmosphere
            1. How was the feel of the unit on that day? Busy, quiet?
        iii. People and relationships among team members
            1. Who was working with you?
            2. Did you know these clinicians? For how long?
            3. Did you know the family?
        iv. Particular and specific instances that illustrate explanatory statements- how did the team decide to extubate the mechanically ventilated patient?

4) Could you provide one take-home point or conclusion that you feel explains the dynamics of how the team worked together when caring for this one patient?

5) How or in what ways do you think the ICU team worked really well together to care for this patient?
6) How or in what ways do you think that the ICU team could have worked together better to care for this patient?

If time allows, probe for any big categories of content:

7) Generally speaking, are there common patient care issues that tend to result in "poor" teamwork?
    a. If so, what are they and why do you think there tends to be poor teamwork around this/these issues?

8) Are there common patient care issues that tend to result in good teamwork?
    a. Is so, what are they and why do you think there tends to be good teamwork around these issues?

9) Also, we've observed in the CCMU and we are curious to hear about when ABCDE is delivered in terms of what time during the day? Can you provide some thoughts about that from your perspective?

10) Can you also walk me through the process by which you wean and then extubate mechanically ventilated patients?
    Probes
    a. Who else is present? Do you communicate with these individuals?
    b. Who initiates the weaning?

11) What does patient and family engagement mean to you?

APPENDIX A-2

Interview Guide for Member-checking Interviews with Clinicians (Aim 1)

Instructions to begin interview:

1. Introduce yourself
2. Describe objective of interview

The purpose of this interview is to get your perspectives on whether a list of tasks I will show you are consistent with your average clinical workflow and that of your colleagues regarding delivery of care to mechanically ventilated patients. This brief interview will be audio-taped so that we have an accurate record of your thoughts. Once the interviews have been transcribed, the recording will be destroyed and the transcription will contain no identifying information.

Do you have any questions before we begin?

1. Establish rapport.
    a. Can you tell me a little bit about how long you have worked in this ICU?

2. Show task list. Please focus on the collaborative activities and enablers to collaborative activities listed for the interviewee's role.
    a. Do these collaborative activities resonate with your average workflow when caring for a mechanically ventilated patient? Can you give any examples of these activities from your own clinical practice?
    b. Are there any collaborative activities we missed?
    c. Here is an additional list of collaborative activities we are considering incorporating into the final task list. Do you think they should be included to capture a more accurate representation of your average workflow?
    d. Do these enablers to collaborative activities resonate with your average workflow when caring for a mechanically ventilated patient? Can you give any examples of these enablers from your own clinical practice?
    e. Are there any enablers to collaborative activities we missed?

3. Are there any collaborative activities or enablers that you think may be incorrect or unclear?

4. Here is the list of enablers and collaborative activities side by side. We think some of these enablers and collaborative activities may be directly related. Can you identify any specific relationships between the enablers and collaborative activities?

APPENDIX A-3

Paper version of Time-motion Tool

Observer Initials: Date: Clinician role observing: RN/RT/MD

Obs.					
Duration					
Time					
Clinicians	☐ Nurse (RN) ☐ Resp. Therap. (RT) ☐ Fellow MD ☐ Attending MD ☐ Resident MD ☐ Intern MD ☐ Other:	☐ Nurse (RN) ☐ Resp. Therap. (RT) ☐ Fellow MD ☐ Attending MD ☐ Resident MD ☐ Intern MD ☐ Other:	☐ Nurse (RN) ☐ Resp. Therap. (RT) ☐ Fellow MD ☐ Attending MD ☐ Resident MD ☐ Intern MD ☐ Other:	☐ Nurse (RN) ☐ Resp. Therap. (RT) ☐ Fellow MD ☐ Attending MD ☐ Resident MD ☐ Intern MD ☐ Other:	☐ Nurse (RN) ☐ Resp. Therap. (RT) ☐ Fellow MD ☐ Attending MD ☐ Resident MD ☐ Intern MD ☐ Other:
Location (select one)	☐ Patient Rm ☐ Hallway ☐ Nurse Station ☐ Break room ☐ Other:	☐ Patient Rm ☐ Hallway ☐ Nurse Station ☐ Break room ☐ Other:	☐ Patient Rm ☐ Hallway ☐ Nurse Station ☐ Break room ☐ Other:	☐ Patient Rm ☐ Hallway ☐ Nurse Station ☐ Break room ☐ Other:	☐ Patient Rm ☐ Hallway ☐ Nurse Station ☐ Break room ☐ Other:
Activity	☐ Enabler ☐ Collaborative Act.	☐ Enabler ☐ Collaborative Act.	☐ Enabler ☐ Collaborative Act.	☐ Enabler ☐ Collaborative Act.	☐ Enabler ☐ Collaborative Act.
Type					

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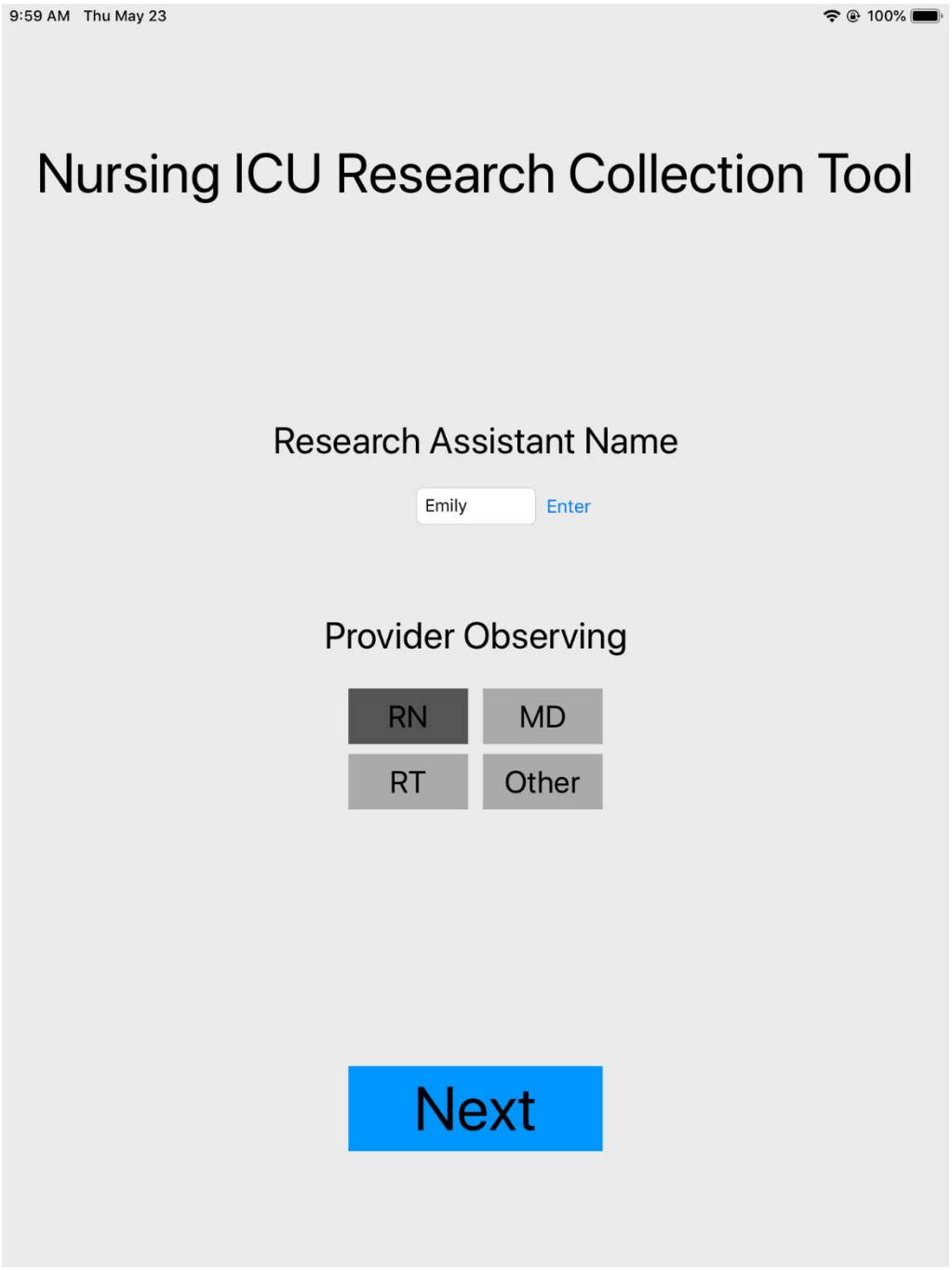
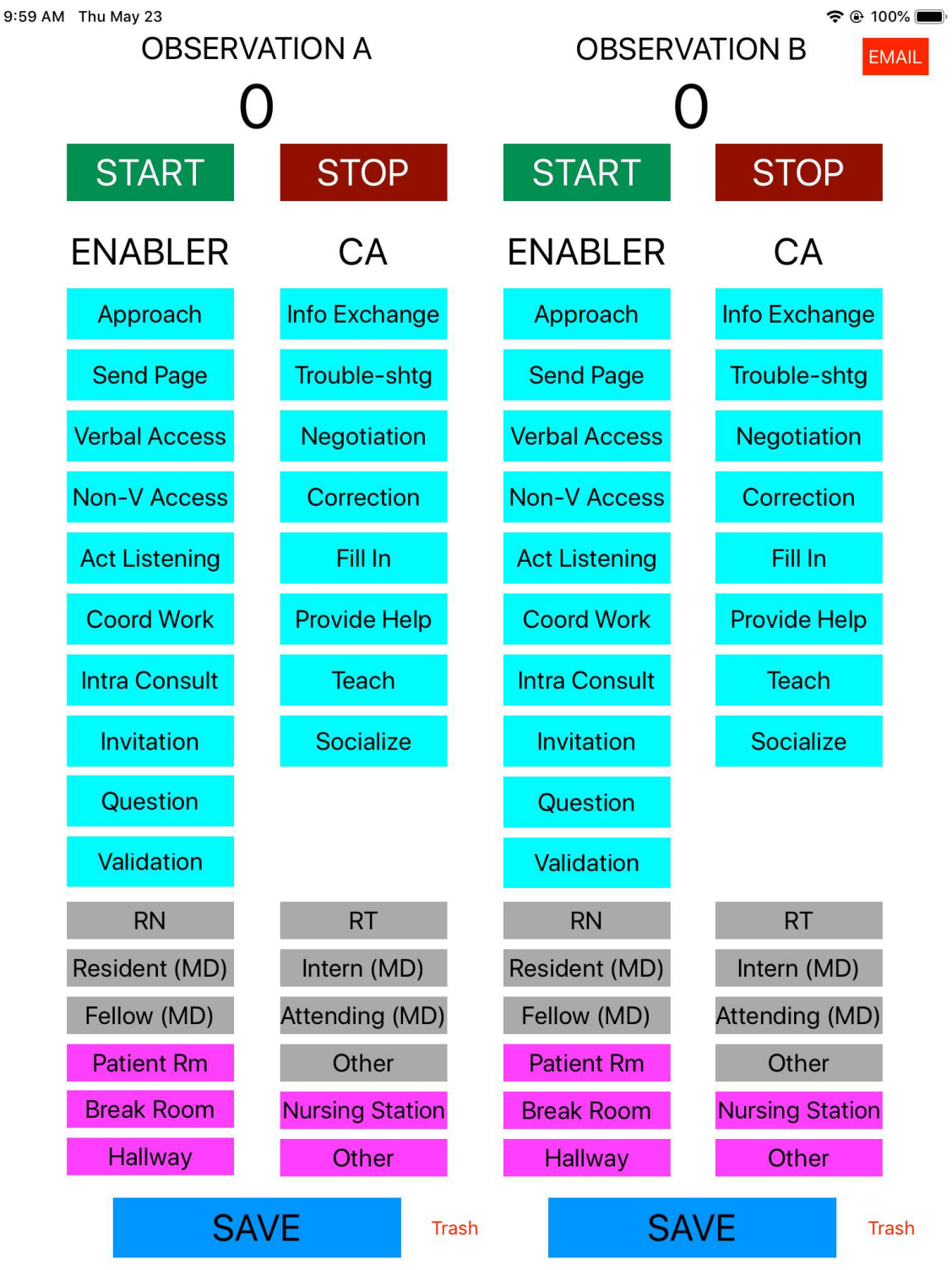
Enablers		Collaborative Activities	
1. Approach: Deliberately walking up to another professional to engage in a collaborative activity.	6. **Propose reflexive question:** Asking another professional to explain rationale for decision. An approach to promote further dialogue when there is disagreement.	1. **Information Exchange:** Short interaction during which two or more professionals communicate objective clinical information and/or a subjective assessment	6. **Provide help:** Assisting another professional in completing his/her professional duties and/or responsibilities. (i.e. bring supplies or helping with a patient care task)
2. Send page: Using mode of technology to contact another professional.	7. **Active Listening**: Attentive listening (i.e. not multitasking) when another professional is communicating.	2. **Trouble shooting:** After a patient care issue arises, two or more professionals engage in a dialogue to identify the root cause of the issue and identify potential solutions.	**7.INTERprofessional teaching:** Provide didactic or hands-on skills training to another professional.
3. **Verbal Accessibility:** Clinician explicitly stating that he/she is available to another professional.	8. **INTRAprofessional consult:** Seek input from a fellow professional (RN/RN, RT/RT, MD/MD) to clarify a decision before contacting another professional.	3. **Negotiation**: A dialogue between two or more professionals to achieve consensus regarding a change in patient care.	8. **Socializing:** Engage in non-clinical related conversations or making jokes with other professionals.
4. **Non-verbal accessibility:** Clinician positioning him/herself in a location to indicate he/she is available.	**9.Coordinate workflow:** Identifying a mutual time to complete a patient care task.	4. **Correction:** Communicate the "correct" or most up to date information/assessment if the info communicated by another professional is incorrect.	
5. **Invitation:** Explicit ask for participation by one professional to participation.	10. **Validation:** Providing verbal or non-verbal (i.e. head nod) endorsement to another professional.	5. **Fill in the gap:** Step-in or supplement another professional's transfer of information.	

APPENDIX A-4

Screenshot of iOS Application Version of Time-motion Tool




9:59 AM Thu May 23
100%
OBSERVATION A
OBSERVATION B
EMAIL
0
0
START
STOP
START
STOP
ENABLER
CA
ENABLER
CA
Approach
Info Exchange
Send Page
Trouble-shtg
Verbal Access
Negotiation
Non-V Access
Correction
Act Listening
Fill In
Coord Work
Provide Help
Intra Consult
Teach
Invitation
Socialize
Question
Validation
RN
RT
Resident (MD)
Intern (MD)
Fellow (MD)
Attending (MD)
Patient Rm
Other
Break Room
Nursing Station
Hallway
Other
SAVE
Trash
SAVE
Trash

APPENDIX A-5

Table 30

Description of Video Training Material

Scenario	Clinician Roles	Location	Collaborative Activity	Enabler
1	• Nurse • Fellow MD	Patient room	Information exchange (Physician AND Nurse)	Approach provider (Physician)
2	• Nurse • Respiratory Therapist	Patient Room	Troubleshooting (RT AND Nurse)	None
3	• Nurse • Resident	Nurse station	Negotiation (Nurse)	Approach (Nurse)
4	• Nurse • Respiratory Therapist • Fellow MD • Resident 1 • Resident 2	Hallway	Information exchange (Nurse) Correction/clarify (Nurse)	Invitation (Fellow MD)
5	• Nurse • Respiratory Therapist • Fellow MD • Resident 1 • Resident 2	Hallway	Fill in gap (RT) Information Exchange (MD)	Reflexive question (RT) Validation (Fellow MD)
6	• Nurse • Respiratory Therapist	Nurse station Patient room	Provide help (Nurse)	Approach (RT) Coordinate time (RT AND Nurse) Invitation (RT)
7	• Nurse • Respiratory Therapist • Fellow MD	Hallway	None	Verbal accessibility (Fellow MD)
8	• Nurse • Respiratory Therapist	Patient room	None	Approach (Nurse) Non-verbal accessibility (Nurse)
9	• Nurse • Respiratory Therapist • Fellow MD • Resident 1 • Resident 2	Hallway	Interprofessional teaching (Nurse)	Invitation (Fellow MD) Active Listening (Fellow MD)

10	• Nurse 1 • Nurse 2	Nurse station	None	Intraprofessional consult (Nurse) Paging provider (Nurse)