Identifying contextual and structural factors contributing to organizational sustainability in pediatric healthcare

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Identifying Contextual and Structural Factors Contributing to Organizational Sustainability in Pediatric Healthcare

by
Sara Malone, LCSW

A dissertation presented to
Brown School
of Washington University in
partial fulfillment of the
requirements for the degree
of Doctor of Philosophy

May 2022
St. Louis, Missouri
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“It is not from ourselves that we learn to be better than we are.” – Wendell Berry

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Sara M. Malone

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May 2022
ABSTRACT OF THE DISSERTATION

Identifying contextual and structural factors contributing to evidence-based practice sustainment in pediatric healthcare

by

Sara M. Malone

Doctor of Philosophy in Public Health Sciences

Washington University in St. Louis, 2022

Professor Douglas A. Luke, Chair

Every year, millions of children seek health care for acute and emergent needs. However, evidence-based care is not currently delivered to every child. Even when teams implement care discoveries designed to improve outcomes, they are often not sustained over time. All children should receive care that is in accord with current evidence-based guidelines, and those evidence-based practices must be effectively maintained over time. It is imperative to understand how to sustain care improvements in the clinical setting. Sustainability capacity allows us to understand the organizational factors that ensure care delivery over time. While there has been an increased focus on sustainability, the field is still in its infancy. This study contributes to the field of sustainability by addressing three aims: (1) identifying determinants of clinical sustainability, (2) exploring the clinician perspective on sustainability and clinician roles contributing to sustainability, and (3) assessing the communication structures of antimicrobial stewardship teams and their influence on sustainability. Results highlight the validity of the sustainability capacity measure and highlight important contextual determinants of sustainability capacity.
Future research should continue to focus on the factors that determine sustainability as well as transition to understanding interventions to improve sustainability of evidence-based care.
Chapter 1: Introduction
Background and Significance

In a single year, around 17% of children, or over 12 million children, in the United States seek care in the setting of an emergency department [1]. In 2012, around 6 million children were admitted to inpatient hospital stays for at least one night [2]. In a meta-analysis of nursing based practices, outcomes were 28% better for patients when they received evidence-based care [3]. It has been consistently estimated that as low as 10-20% of care provided is evidence-based [4-6]. This means that over 5 million children admitted annually to inpatient settings might not be receiving the best medical care, or care that actually works.

Yet, medical innovations are developing as rapidly as ever. Many scientific discoveries provide the opportunity to decrease morbidity and mortality across all disease states. However, evidence-based care delivery will fail to reach its full potential in health systems unless and until interventions can be both introduced and sustained reliably. Within pediatric healthcare, implementation research is still rare and there have not been studies specifically focused on how to sustain practices.

There is a persistent lack of understanding of how to sustain evidence-based care delivery in these complex delivery structures [7, 8]. Medical professionals often lack sufficient training, resources, and time to consistently apply research results that support the sustainability of evidence-based practices. Even among the small percentage of evidence-based interventions that are implemented, many of those are implemented without a sustainability plan and ultimately never reach their potential public health impact [9].

There is a critical need to better understand factors that lead to and support sustainability, which will ultimately inform interventions that foster ongoing evidence-based practice. The care
provided in the hospital setting is different from mental health clinics or public health programming. In hospital systems, quality improvement was utilized in an attempt to respond to these concerns regarding patient safety and quality care. The clinical setting has different demands on personnel, relationships to patients, and organizational influences dictating how the system functions. The problem of implementing and sustaining evidence-based practice is situated uniquely at the intersection of quality improvement and implementation science. Responding to these problems advances our understanding of the structures and processes that contribute to sustained evidence-based practice. Ultimately, this will result in improved healthcare for all children.

Quality of Care

Quality of care, has served for decades as a critical proxy for understanding the functioning of healthcare systems within the United States. The Institute of Medicine’s (now the National Academy of Medicine) definition of quality of care, which has been adopted by health services research, is “the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge” [10]. Donabedian suggests that quality of care is comprised of different components of the healthcare delivery system and could be best measured through assessing care settings, care processes, and care outcomes [11]. After the Institute of Medicine’s landmark report on the state of healthcare in the United States, more resources have been dedicated to measuring and improving quality within our hospital systems [12]. This has been a focus of both clinical practice and programs as well as research.
Many different approaches to healthcare improvement have emerged, with numerous substantive fields (e.g., quality improvement, health services research, improvement science) developing interest in how to advance quality care. These approaches affect many aspects of evidence-based practice and improvement, spanning from the translation of new evidence to a narrow focus on reducing individual patient error and increasing safety [12-15]. For this dissertation, evidence-based practice is a central orienting approach. Evidence-based practice has been defined as “the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients” [16].

The benefit of evidence-based practice in clinical care assumes a basic iterative healthcare improvement ‘loop’. In this system, scientific advances are translated into new clinical practices, these practices are disseminated and implemented within healthcare settings and systems, the new practices are sustained over time, leading ultimately to improved patient health. Ongoing evaluation of these processes and outcomes is fed back to clinical researchers, which encourages further scientific and clinical improvements. While projects are constantly initiated and changes made in healthcare, there is still a knowledge gap of what it takes to more efficiently and effectively deliver and maintain new clinical healthcare advances [17, 18].

**Sustainability in Healthcare**

The field of implementation science has brought attention to implementation and service outcomes in addition to clinical outcomes for patient care [19-21]. Within implementation science taxonomy, the field has differentiated sustainability and sustainment. Interventions, practices, and programs must be sustained to fully maximize their impact. When sustainability is ignored, important programs cease to be delivered and improved health outcomes are never
delivered. Little is understood about sustainability and increasing the capacity to sustain interventions, even with increased interest in its conceptualization and measurement [22]. Sustainability has been described as “one of the most significant translational research problems of our time” [23]. A recent review found that there are still inconsistent measures and definitions of sustainability in literature combined with little use of theory and poor descriptions of sustainability outcomes and interventions [7]. Below is an outline of how this dissertation will use the concepts of sustainability, clinical sustainability, and sustainment.

**Defining sustainability**

Sustainability research has become more prevalent over the past two decades, with research about sustainability theory and measurement becoming more prevalent [8, 17, 24]. Sustainability has been conceptualized both as a process and an outcome, and many definitions have been used to describe the concept [8]. Further, many studies do not provide any definition of how they conceptualize sustainability when it is utilized in research studies [8, 17]. Proctor identified sustainability as an important outcome within implementation science and defined it as “the extent to which a newly implemented treatment is maintained or institutionalized within a service setting’s ongoing, stable operations” [20]. Moore et. al. conducted a review of sustainability literature and defined the concept as “(1) after a defined period of time, (2) a program, clinical intervention, and/or implementation strategies continue to be delivered and/or (3) individual behavior change (i.e., clinician, patient) is maintained; (4) the program and individual behavior change may evolve or adapt while (5) continuing to produce benefits for individuals/systems” [25]. Two systematic reviews have worked to define sustainability. Shelton et al. defined sustainability as “the continued use of program components at sufficient intensity
for the sustained achievement of desirable program goals and population outcomes” [8]. Another systematic review focused on sustainability as well as its capacity, which is distinguished below, stating “a program or intervention may be considered to be sustained at a given point in time if…core elements are maintained…and adequate capacity for continuation of these elements is maintained” [17].

These definitions help understand how the field has come to understand sustainability as an outcome of service delivery over time.

Whatever the specific definition, the following three aspects of sustainability are important for us to consider:

*Sustainability is complex.* Although all the determinants of sustainability are not fully understood, it is widely accepted that many different relevant determinants (e.g. social context, professionals, patient factors) need to be studied to better understand what causes sustainability of interventions [20, 26]. Organizational capacity is seen as contributing to sustainability but there have not been specific determinants identified nor has work been conducted to understand what is predictive of long-term sustainment. While defining and evaluating sustainability is complex, so is the discovery of what contextual factors are predictive of sustained interventions over time.

*Sustainability is dynamic.* While the definitions above suggest that sustainability is an important outcome in implementation science and practice, sustainability has also been described and
conceptualized as a process [22]. This process of sustaining a practice indicates that the construct must be considered earlier in the implementation process. Additionally, there is important feedback and evolution to the process of sustaining an intervention or practice in a given environment [27]. These concepts draw on systems science ideas of feedback and the constantly changing context that results in a need to continually adapt and develop.

*Sustainability is context-dependent.* Although there are foundational ideas that shape the definition of sustainability, there are aspects that are dependent on the context of the evidence-based intervention. Sustainability outcomes are dependent on these contextual factors and understanding the outcomes requires knowledge of the environmental context within which the system is embedded [28]. Thus, understanding clinical sustainability is unique when contrasted to other settings, such as public health or social service programs. Knowledge of the contextual environment and the uniqueness of the setting is required to better understand the sustainability of evidence-based interventions.

**Defining clinical sustainability**

It is important to adapt concepts of sustainability to the specific contextual characteristics of clinical and healthcare delivery settings [7]. In particular, conceptualizations of sustainability that have been developed within the context of public health programs, or policy development and implementation need to be adjusted before applying them to the very different environments (e.g., health clinics, hospitals). The clinical healthcare environment contains unique provider dynamics, workflow challenges, and complexities to overcome when evaluating sustainment of
practice over time. Clinical sustainability is meant to include a variety of healthcare settings, inclusive of both inpatient and outpatient medicine. Comprised of large multi-professional teams, these settings encompass a range of subspecialties and different patient populations.

Clinical practices at the unit and team level are less reliant on programmatic development and are better understood through practices and procedures that occur. For example, clinical practices might focus on a new drug or procedures as opposed to the development of a new clinic that individuals could visit. This requires a different orientation to the concept and also indicates that the practice is less reliant on external factors broadly. Instead, clinical sustainability relies heavily on frontline providers who are conducting activities that are highly integrated with the rest of the workflow. Finally, the time horizon for implementation and impact is often shorter in clinical sustainability, allowing patient and system-level changes to be seen more immediately by those providing care.

To understand all of the differences highlighted above, clinical sustainability must be understood as a concept to be different from sustainability more broadly. We have defined clinical sustainability as “the ability of an organization to maintain structured clinical care practices over time and to evolve and adapt these practices in response to new information”, and this is the definition used in this dissertation [29].

*There are still major gaps in understanding clinical sustainability.* Sustainability is complex, dynamic, and context-dependent within clinical settings and healthcare systems. Therefore, it is necessary to better understand how we measure, conceptualize, and intervene on sustainability to improve health delivery and health outcomes.
Sustainment/maintenance

Sustainment and/or maintenance are the most common terms used to describe the ongoing penetration of a practice into a setting [30]. Sustainment is defined as the outcome of continuing to deliver an intervention or program [27, 31]. Sustainment, therefore, is the outcome of the continued use of the intervention where sustainability and sustainability capacity focuses on the factors that exist to promote the ongoing use of the intervention [30]. This dissertation focuses on sustainability and its determinants, with the conceptual understanding that sustainment would be the practice outcome for the intervention or program where sustainability is high.

Sustainability capacity

Sustainability capacity is distinct from sustainment. Sustainment, as described above, is an outcome. Sustainability capacity is used to describe the determinants of sustainment, and was described as a key aspect of sustainment in a review by Wiltsey Stirman et al [17]. In public health, sustainability capacity has been defined as the “existence of structures and processes that allow a program to leverage resources to effectively implement and maintain evidence-based policies and activities” [32]. Organizations who maintain this capacity for delivering the intervention or practice have a higher likelihood of sustainment.

Conceptual Frameworks

This work is situated at the intersection of quality improvement and implementation science. Quality improvement, while having a scientific and theoretical basis, is a more applied science with the ultimate goal of improvement of services and processes within the hospital system [13,
Stemming primarily from nursing practice and literature, quality improvement has been developed focusing on the application of evidence and rapid problem-solving in clinical environments. Batalden and Davidoff define quality improvement in healthcare as “the combined and unceasing efforts of everyone—healthcare professionals, patients, families, researchers, payers, planners, and educators—to make the changes that will lead to better patient outcomes (health), better system performance (care) and better professional development” [13]. In 2000, a landmark paper was published noting a 17-year gap between discovery and implementation of evidence-based practices [34]. Since then, a field of implementation and dissemination science has emerged, attempting to understand the gap between discovery and use in practice settings. Implementation science has been defined by the National Institutes of Health as “the study of methods to promote the adoption and integration of evidence-based practices, interventions and policies into routine health care and public health settings” [35]. Unlike the medical sciences field of quality improvement, implementation science emerged out of a multitude of theoretical domains, ranging from education to mental health to policy.

Overview of Useful Conceptual Frameworks

Recently, more attention has been given to frameworks that highlight and explain both sustainability and sustainment of evidence-based practices. While much of this work is still in its infancy, multiple frameworks have informed the conceptual foundations of this dissertation research (see Figure 1 below).

First, and most important to the dissertation is the clinical sustainability framework [36]. This was adapted from a sustainability framework put forth by Schell et. al. [32] and Luke et. al. [37]. These all describe organizational capacity determinants that can be linked to the ability to sustain
a program over time. The seven domains in clinical settings, illustrated in Figure 1 below, and central to my dissertation work, are: 1) Engaged staff and leadership—frontline and administrative staff that are supportive of the practice; 2) Engaged stakeholders—other individuals, like patients or parents/caregivers, are also supportive of the practice; 3) Organizational Readiness—organizational internal support and resource needed to effectively manage the practice; 4) Workflow integration—the extent to which the practice fits well into how work is done or will be done; 5) Implementation and training—the process and efforts that have to happen to maintain a practice; 6) Monitoring and evaluation—a process to evaluate the practice to determine effectiveness; and 7) Outcomes and effectiveness—using monitoring and evaluation to determine that the practice is having a beneficial outcome for clinicians or patients.

A measure exists both for public health and clinical medicine programs to assess organizational capacity for sustainability [37-39]. This framework and measure are utilized in all three aims of the dissertation.

In addition to the clinical sustainability framework, the dynamic sustainability framework provides a feedback-based understanding of sustainability and the contexts within which interventions are positioned [27]. The framework describes the practice setting as crucial to understanding sustainability and calls for the measurement of organizational capacity. Further, dynamic sustainability incorporates continual assessment and adjustment in response to feedback to maximize the benefit of evidence-based practice. Embedded in this approach to sustainment is an understanding the staff is crucial as stakeholders to inform ongoing practice as well as conceptualize the sustainment of an intervention [27]. A dynamic understanding of sustainability and the systems involved in medical care is underlying the organization and design of the dissertation.
Complexity theory has both been praised for its promise in health services research while also being critiqued for having conceptual confusion [40, 41]. Complexity theory also understands every system as complex, but attempts to understand the individual interactions, feedback, and constraints on behaviors of those who are involved within a system [42, 43]. While complexity theory views each actor within the system as following fairly simple rules, or behaviors, complexity occurs when each of these simple behaviors multiples into a system of behaviors [44, 45]. Phelan also highlights that complexity theory aims to understand the individuals in a system through an exploratory lens, as opposed to a systems science confirmatory look at the relationships between stocks and flows [44]. A systematic review found that complexity theory is increasingly used but has not been consistently operationalized [40]. This review determined that authors utilized complexity theory to conceptualize design and data analysis most often, but authors are not consistent in their description of how the theory was integrated or informed the work completed [40]. It has been defined as “the science of moving in a nonlinear and interactive manner where unpredictable outcomes are often realized; organizations are described as ever-changing collections of individuals and conditions in the organization; and patterns of interaction among individuals and connections are made in day-to-day practices among and between individuals” [46, 47]. Recent work has called for use of complexity theory to expand the understanding of different layers of context in healthcare and to better research quality in health [48]. Complexity theory is present across the conceptual underpinning of much of the dissertation but is highlighted in Aim 3 through the choice of social network analysis for the methods.

Starting from an assumption that contextual determinants were important and under-appreciated in quality improvement, a team of experts created the Model for Understanding Success in
Quality (MUSIQ) [49]. This model focuses on system-level intervention and identified 25 different constructs deemed important in understanding quality improvement success. These constructs include (not a comprehensive list): team diversity, organizational maturity, physician involvement, and data infrastructure. These are nested under different domains. This work has been utilized in the evaluation of many different projects but has not been published as informing the development of a quality improvement initiative at this time. While created on an organizational level, a group of researchers utilized the theory to evaluate implementation data in conjunction with policy documents to understand healthcare planning in Nigeria [50]. This study suggested that a shortcoming of the MUSIQ model was that no relative weights were given to the constructs, such that an organization could potentially score highly overall, but failure in one specific construct might eliminate all potential implementation efforts [50]. A systematic review conducted utilizing the MUSIQ framework highlighted that many current publications of quality improvement efforts do not report the contextual factors that might be relevant, and that inclusion in project write-ups would help understand varying degrees of success within improvement projects [51]. The determinants that are highlighted by the MUSIQ framework are also present in the clinical sustainability framework and helped inform the contextual aims (Aims 1 and 3) of the dissertation.

Proctor et. al. put forth a taxonomy of outcomes for implementation science, both providing uniform definitions for the field and also giving implementation scientists a set of outcomes to prioritize when conducting research and evaluation [20]. While most people cite the outcomes they are using for research, this work also put forth a foundational concept of a changing equation for implementation success, based on project or context. Much subsequent work in the field cites this work when creating an evaluation plan. This study consists of a set of outcomes
and does not put forth research connecting determinants to outcomes or suggesting how outcomes should be chosen based on context and project. Proctor suggests in her outcomes that sustainability be considered. Her definitional work on sustainability and its inclusion as an outcome are informative to the foundation of this work.

Finally, the Exploration, Preparation, Implementation, Sustainment framework (EPIS) is a process model that also highlights the contextual factors that are relevant within the knowledge translation process [52]. For this work, the context and relevant factors were informative, particularly in Aim 2. Within the process, the framework describes that inner and outer context, factors about the innovation, and bridging factors are all important in understanding how knowledge translation occurs [52-54]. Since this dissertation uses three common programs and all academic medical centers, the context is similar for all sites. EPIS describes potential multiple layers of the inner context, although the hospital has some unique overlap between the inner and outer context. However, the principles of layered context, innovation factors, and bridging factors were all relevant to the dissertation.

**Guiding Conceptual Framework**

To guide and structure this dissertation, a conceptual framework was created that was informed by the literature from these major fields of healthcare improvement. Multiple conceptual frameworks from quality improvement and implementation science helped structure the framework for the dissertation, including one context theory (Complexity Theory), three determinant theories (EPIS, Model for Understanding Success in Quality, and Sustainability Theory), and Proctor’s Outcomes to help aid in defining and measuring sustainability [20, 32, 48, 49].
Figure 1 presents the conceptual framework for this dissertation. This figure conceptualizes how clinical sustainability interacts with the healthcare setting. The left side of the figure highlights the importance of determinants, including organizational context and structure, on clinical sustainability capacity. The context of this work encompasses multiple pediatric healthcare settings, but all have the same type of system. The study will focus on understanding the different ways that context and structure interact with clinical sustainability, comprised of seven domains. These seven domains have been published as a cohesive measure, but also represent a framework for understanding sustainability capacity [36]. The conceptual framework also highlights the idea of feedback that these constructs can have on each other, which was informed by the dynamic sustainability framework as well as complexity theory. On the right side of the figure, the importance of these constructs on the outcome of sustainability and subsequently patient health outcomes is illustrated.
Purpose of the Dissertation

The goal of this dissertation is to enhance our understanding of sustainability in clinical health settings and to validate specific constructs and measurement methods related to clinical sustainability. The dissertation focuses on the intersection of quality improvement and implementation science in pediatric settings. It argues that quality improvement can inform sustainability research and determinants that are important for assessing sustainability in pediatric healthcare. Second, the project uses qualitative methods to analyze how sustainability is understood by frontline clinicians in pediatric healthcare delivery. Finally, the project assesses communication structures in one pediatric setting as a case study for understanding social structure and boundary spanning as influential in clinical sustainability. It does so through the following three study aims and related research questions:
Specific Aims and Research Questions

Specific Aim 1: Identify the inter-relationships among organizational characteristics, quality improvement capabilities, and reported clinical sustainability in three different types of clinical programs.

Research Question 1: What specific organizational factors influence clinical sustainability capacity?

Research Question 2: How does quality improvement capability correspond to sustainability of clinical programs?

Specific Aim 2: Understand clinician experience and roles contributing to sustained pediatric clinical programs and their perceptions of the relative importance of clinical sustainability domains within these programs.

Research Question 1: In what ways do frontline clinicians think about sustainability (i.e., perceptions and beliefs) within their clinical care settings?

Research Question 2: How do frontline clinicians understand the constructs that contribute to sustainability?

Research Question 3: What are the roles that clinical staff have in the sustainment of evidence-based practices?

Specific Aim 3: Assess the communication structures of clinical antimicrobial stewardship teams and their influence on reported clinical sustainability across nine hospitals.

Research Question 1: What are the patterns of communication among stewardship teams?
i. What are the types of general and collaboration-specific communication that occur regarding antimicrobial stewardship in surgical settings?

ii. What are the roles of social networks in knowledge acquisition among different subspecialties?

Research Question 2: How do communication networks of stewardship teams relate to sustainability capacity?

The dissertation will investigate these three aims and the associated research questions within three distinct, yet interrelated, studies (through a three-paper model). By answering these questions and each specific aim, this research will enhance understanding of the different systemic factors within medical settings that contribute to sustained implementation. Together, these papers will provide evidence about what factors can ultimately contribute to sustainment of evidence-based practices. This work will help healthcare researchers and practitioners inform initial implementation as well as to develop ongoing plans to ensure sustainability, thereby maximizing the public health impact of evidence-based interventions. This work is innovative theoretically as it further develops sustainability theory at the intersection of quality improvement and implementation science. The use of systems methods to assist with construct validation is also innovative in implementation science. Finally, the work is significant in its potential impact on both health researchers and practitioners. Research on sustainability practices can help develop programs that better plan for and measure sustainability of other evidence-based practices and programs. This work also advances the methodology of using systems science and other approaches for measurement development and validation. Additionally, these clinical programs can be improved by better understanding different dimensions to their clinical programs. All of these practices are impactful in
pediatric healthcare and will be better delivered after studying the ways in which different determinants impact the practice’s sustainment.

Methods

Understanding, selecting, and utilizing appropriate methods is critical for both research and practice of healthcare improvement and integration of evidence-based practices in clinical settings. Research questions are not able to reliably (or validly) be answered without the correct methods, and enhanced practice (and subsequent outcomes) becomes impossible without the right methods and measures to guide change. Further, methods need to be aligned with the theory that has been chosen to structure the problem. Braithwaite highlights the ability of multilevel methods to answer ‘what?’ questions, network analysis and other computational methods to model systems and subsystems, and qualitative ethnographic methods to help with questions about ‘how?’ [48]. The methods for this dissertation are aligned with these recommendations and provide an opportunity to better understand the healthcare system and potential areas for improvement. Work in improvement sciences will have its greatest effects if driven by rigorous design and analytics in both practice and research.

The following two classes of research methods are particularly important for achieving the goals of this dissertation:
One of the ways that quality improvement and implementation science have attempted to achieve a better understanding of context is through organizational assessment. This includes assessing capacity, readiness to change, and other aspects of flow throughout the system. Although these fundamental concepts emerged from human relations and psychology, they have been adapted and defined within healthcare contexts [55]. In the Institute of Medicine’s work *To Err is Human*, the focus was on the idea of a culture of safety, which ignited the quality improvement interest in understanding the culture of a given setting as it relates to improvement initiatives [12, 56]. Success in quality improvement initiatives has been linked to resources, leadership, and infrastructure – all subconstructs that have been categorized under the concept of organizational context [57]. Within implementation science, the understanding of organizational capacity and context is broader, including things such as resources, personnel, organization size, climate and culture, infrastructure, and policies [58]. Similarly, within both fields, organizational capacity has been theoretically and empirically linked to service delivery and ultimately patient outcomes, as well as being associated with an increased uptake of evidence-based practice [57, 59].

A growing focus on capturing context, as mentioned above, has created a demand for ways to understand organization structure as well as context (sometimes referred to as culture) [60]. However, most of the work conducted has been through surveys that are completed by a handful of employees in a given setting. A measure, or measurement strategy, for collecting true information about a setting or system would greatly improve the ability to describe what happens through the change and improvement process. The ability to capture appropriate data, along with appropriate study and analytic design, would also lead to more insight on causality and information about what might be truly generalizable across settings.

Braithwaite et. al. argue for network analysis, and other computational analyses, to understand systems in
conjunction with ethnographic methods to help triangulate understanding of the complexity in healthcare systems [48].

Social Network Analysis

Social network analysis has been defined as a method “which seeks to predict the structure of relationships among social entities, as well as the impact of said structure on other social phenomena” [61]. The use of network analysis in implementation science has been identified as a way to study both the processes and outcomes of implementation [62, 63]. Being able to model these relational aspects within healthcare also allows those attempting to better understand the system to have a more complete understanding of context, which is of fundamental importance within implementation science [63, 64]. The utilization of this modeling technique can quickly allow researchers and practitioners to understand how individuals or other units of interest are uniquely positioned within a network, providing information and allowing for a more effective and efficient implementation plan to be developed. Utilizing social network analysis along with other implementation science methods would allow for a more comprehensive understanding of context than is provided by simply using methods popular within health services research or quality improvement.

The appropriate use of these methods would help both researchers and clinicians to better conceptualize what is occurring and how the people and resources within the system can help propel or hinder the implementation of the best evidence-based care. While most professionals are understood to be resilient, well-intentioned, and hardworking, the use of the methods helps explain the exponential changes that occur as these individuals work within the systems we have created. These methods help give an explanation to the factors that surround individuals and organizations and make such a large impact on care delivery.
Integrating Multiple Methods and Types of Data to Validate Clinical Sustainability Constructs

The work is based on robust and rigorous analytic methods drawn from a broad toolset - including quantitative, qualitative, and systems (network) data study designs. In implementation science research, the methodological work will be innovative in the integration of social network methods to help with measurement validity, and to complement the other quantitative and qualitative research methods.

Conclusion

Health threats to children continue to evolve. While innovations are developed to improve mortality and morbidity, there are still large discrepancies in who receives evidence-based care in clinical settings. This demands attention to how we continue to deliver care for children in their most vulnerable state. Even when the initial uptake of new evidence-based practices is high, these beneficial practices often cease to be delivered over time.

Thus, understanding, measuring, and improving the sustainability of evidence-based healthcare practices is vital to improving the quality of care delivered to children and communities. While the challenge has been acknowledged, there remains a gap in the rigorous measurement of sustainability as well as understanding its relevant determinants.

Given that this healthcare delivery problem is complex and understudied, this dissertation uses a variety of methods that are necessary to understand how to improve quality care in these complex environments [48]. The dissertation combines theory and methods from implementation science, quality improvement, and health services research to examine contextual and structural factors that contribute to sustained
evidence-based practices in hospital systems. All of these aims are targeted at understanding of sustainability of evidence-based practices in pediatric settings through analysis of different contributing variables. This work was conducted and analyzed with attention to the multiple professions involved in healthcare delivery. These analyses will inform research and practice efforts to improve healthcare delivery within pediatric hospital settings.
Chapter 2: Contextual Factors Contributing to

Sustainability in Pediatric Healthcare
Background

The importance of sustainability

While recent implementation science work has focused on improving how programs and interventions get initially implemented within complex settings, the impact of an evidence-based intervention is not fully realized without appropriate sustainment over time in clinical settings. Although the estimates have varied, it has been reported that as few as 4% of healthcare practice changes result in reported sustainable changes [9]. In other fields, studies have consistently shown that fewer than half of practice changes are sustained [17, 24].

Sustainability has been defined as “the extent to which an evidence-based intervention can deliver its intended benefits over an extended period of time after external support… is terminated” [65]. While research on sustainability is increasing, it is still relatively poorly understood [49, 66, 67]. One important research opportunity is identifying the determinants of successful sustainment of evidence-based interventions [20, 26]. Some examples of relevant determinants include individual stakeholders, interprofessional relationships, and organizational culture [8, 23, 27, 37]. While there has been work initially conceptualizing some of these determinants of sustainability capacity, there is still a gap in understanding all of the factors that influence sustainability. It is crucial to advance the study of sustainability determinants and theory in clinical settings. This will help ultimately understand how to intervene to ensure sustainment of evidence-based practices.

The importance of context in clinical settings

One particularly important class of determinants of sustainability are characteristics of the context within which the intervention is carried out. Context has been defined by May et al as “the physical,
organizational, institutional, and legislative structures that enable and constrain…people and procedures” [68]. It follows, then, that understanding the outcomes requires knowledge of the environmental context within which the system is embedded [28]. Since these contexts vary by setting, there is a need for specific understanding of these contextual factors within clinical care [69].

Given the relevance of the environment in understanding sustainability and the unique setting of clinical healthcare, it is important to operationalize these concepts in conjunction with each other. The clinical healthcare environment consists of unique provider dynamics, workflow challenges, and complexities to overcome when evaluating sustainment of practice over time. For example, teams are built across different units and professions, meaning that individuals might have different leadership and financial structures. Additionally, the consulting service and the use of the electronic medical record creates communication patterns that might vary based on team, time of day, or acuity of the setting. This understanding of environment is broad and is meant to include a variety of healthcare settings, inclusive of both inpatient and outpatient medicine. Comprised of large multi-professional teams, these settings encompass a range of subspecialties and different patient populations. However, sustainability in healthcare systems has also been historically understudied and poorly defined [7].

Clinical practices are best understood through practices and procedures that occur. This requires a different orientation to the concept and also indicates that the practice is less reliant on external factors broadly. Instead, clinical sustainability relies heavily on frontline providers who are conducting activities that are highly integrated with the rest of the workflow. Finally, the time horizon for implementation and impact is often shorter in clinical sustainability, allowing patient and system-level changes to be seen more immediately by those providing care.

In order to understand all of the differences highlighted above, clinical sustainability must be understood as a concept to be different from sustainability more broadly. Clinical sustainability has been defined as
“the ability of an organization to maintain structured clinical care practices over time and to evolve and adapt these practices in response to new information” [29].

Within pediatric healthcare, there is even less known about sustainability [21]. The workflows, team composition, and relationship to patients and families are just some of the factors that make pediatrics a unique care delivery setting. For example, children’s hospitals require multidisciplinary expertise focused on the unique experiences of childhood. While medical specialists have different training for pediatrics, there are also different professional roles regularly involved in pediatric settings, including clinical social work and child life specialists. Additionally, pediatric hospitals must focus on the parents and caregivers, whereas adult settings are less concerned about caregivers and less frequently have individuals other than the patient providing consent for treatment [70]. The research base for children is more limited due to ethical and practical issues with recruitment and testing [71]. Providers often express concern with the available evidence due to origination in adults and concerns about the imperfect translation of evidence to pediatric settings [72]. All of these differences require special attention to be paid to pediatric health settings.

The relevance of quality improvement for studying clinical sustainability

Health care systems have developed with an emphasis on continual improvement, resulting in numerous theories and methods being developed and refined [14, 15, 33, 73-75]. While there are different histories and approaches to improvement, quality improvement and implementation science are aligned in their desire to improve quality of care as a main priority of the work. Quality improvement is focused on local, context specific problems and rapid correction. Clinical settings have traditionally targeted work on improvement and quality through the field of quality improvement (QI). While having a scientific and theoretical basis, QI is a more applied science with the ultimate goal of improvement of services and
processes within the hospital system [76]. Quality improvement is aimed at realizing improvement within specific metrics, which makes it helpful in project management and execution in busy and under-resourced settings. An emphasis on these practical tools within quality improvement assists with continual actions and analyses that allow for rapid iterations of improvement. This field has similarities to health services research in a focus on patient outcomes through attention to the processes and participants [75, 77, 78].

*Implementation science*, according to Mittman, “generally seeks to develop and rigorously evaluate fixed implementation strategies to address implementation gaps across multiple sites” [79]. This has created a dichotomy where implementation scientists focus on information that can be scaled and generalized, while quality improvement work has aimed its interventions at individual needs and corrections. However, the fields have overlap and integration that has not been fully appreciated nor harnessed.

Sustainability provides an area where the intersection of quality improvement and implementation science could provide insight into how to improve care delivery. Using these two fields allows for a better understanding of the needs to assess impact to the practitioner (quality improvement), system level care outcomes, as well as the integration into the practice environment and process of implementing change (implementation science). This frame suggests that we need to articulate more clearly why sustainability actually leads to improvement, and how we should think of integrating this into a complex system. In order to be successful, work assessing sustainability determinants in healthcare must address this existence of quality improvement as a relevant influence in the field.
Goals and Research Questions

This study works to address some of these gaps in understanding sustainability in pediatric settings and its relationship to quality improvement. This question is being answered by assessing different individual and intervention characteristics, including quality improvement, and their impact on clinical sustainability capacity. These concepts both highlight the ability of an organization to implement and continue to deliver high-quality care.

The study will answer the following questions:

1. What specific organizational factors influence clinical sustainability capacity?
2. How does quality improvement capability correspond to sustainability of clinical programs?

Results from this study will help us to understand if there are any individual, intervention, or quality improvement determinants that contribute to sustainability capacity and could point towards future areas of intervention. This will help advance the science of sustainability through the development of links between determinants and sustainability capacity. This work is innovative in its theoretical underpinnings, bringing implementation science and quality improvement theory together.

Methods

This is a cross-sectional observational study conducted within pediatric academic medical centers in the United States. The study included professionals affiliated with one of three evidence-based clinical programs. The study uses a multilevel modeling framework to assess hospital-level contextual factors and their associations with sustainability capacity.
**Settings**

There are three clinical programs that were included in this study. These three multicenter national hospital programs represent diverse pediatric care settings that have implemented evidence-based clinical practices. Moreover, all sites amongst the three programs were engaged in evidence-based practice change that involve multi-professional teams. Finally, these sites had different organizational backgrounds and resources available, allowing for cross-program comparisons.

The three evidence-based interventions that were assessed were: antibiotic prescribing in clean/clean-contaminated surgeries [80], early mobility within the intensive care unit [81], and massive transfusion blood administration [81, 82]. These are all internationally recognized guidelines and evidence-based practices, and the sample for this study was from a national group of sites that are implementing these practices. Table 1 outlines each intervention and the multi-professional team involved. For ease of describing the practices, the surgical antibiotic practice will be referred to as an antimicrobial stewardship program (ASP) throughout.

<table>
<thead>
<tr>
<th>Practice</th>
<th>Description</th>
<th>Professions</th>
<th>Disciplines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical Antibiotic Prescribing</td>
<td>Appropriate antibiotic prescribing practices in clean and clean-contaminated surgical cases</td>
<td>Pharmacist, physician, physician assistant, nurse practitioners</td>
<td>Infectious disease, surgery</td>
</tr>
<tr>
<td>ICU Liberation/PICU Up!</td>
<td>A care bundle focused on reduction of delirium and sedation to begin early rehab for children that are critically ill</td>
<td>Nurse, physician, respiratory therapy, physical therapy, occupational therapy</td>
<td>Intensive care</td>
</tr>
<tr>
<td>Massive Transfusion Blood Administration</td>
<td>Practices that allow for rapid distribution and administration of blood product</td>
<td>Physician, pharmacist, blood banker</td>
<td>Emergency medicine, Blood bank, Intensive care</td>
</tr>
</tbody>
</table>

Table 1. Description of pediatric practices
Participants & Recruitment

Data were collected during Oct 2020 - July 2021 from 181 multi-professional clinicians involved in the pediatric evidence-based practices described above. While the team compositions were slightly different for each program, they all include multiple types of professionals working together to create practice change.

Individual team leads at each site were identified for each of the three practices. If site leadership agreed, potential participants were identified and recruited to complete the survey over email. Any team members were identified at a site level. This was defined as any individual involved in the relevant clinical care practice in their setting. Participants were contacted twice via email and asked to participate in an online survey that was conducted using Qualtrics (Qualtrics, Provo, UT). Overall, 30 sites participated in the study (Table 2). From these sites, 181 individuals responded to the survey. There were no incentives provided for participating in the study. The study protocol was reviewed and approved by Washington University Human Research Protection Office (202102017).

<table>
<thead>
<tr>
<th></th>
<th>ASP Program</th>
<th>Early Mobility</th>
<th>Transfusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total # of sites</td>
<td>10</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Total # of people</td>
<td>53</td>
<td>88</td>
<td>40</td>
</tr>
</tbody>
</table>

Table 2. Sites and participants by program

Data Sources

The survey data came from three primary sources:

1. Clinical Sustainability Assessment Tool (CSAT) [36] – This measure assesses clinical sustainability capacity and includes seven domains: engaged stakeholders, engaged staff and leadership, organizational readiness, monitoring and evaluation, implementation and training,
outcomes and effectiveness, and workflow integration. There are 35 questions, all completed on a seven-point Likert scale with options ranging from: not at all – to a great extent. There is also a not applicable option for each question. Preliminary reliability information exists for this measure.

2. Clinical Sustainability Assessment Tool Validation Survey – This is an additional set of questions that gathers information about the nature of the evidence-based intervention as well as other organization characteristics that assist in understanding the validity of the CSAT. The questions are grouped into two categories: questions about the organization and those about the intervention. A subset of the organization questions are taken from the Change Process Capability Questionnaire, a quality improvement assessment utilized by the AHRQ [83].

3. Demographic questions – Finally, a set of questions gathered information about the individual taking the assessment. These include the role, profession, and the environment within which the individual usually practices (adult vs. pediatrics, inpatient vs. outpatient).

The full instruments can be found in Appendices A and B.

Variables

The variables of interest for this project can be found listed in Table 3. The primary variable of interest to understand the influence of quality improvement on sustainability capacity was the Quality Improvement Score. The other variables assist with understanding determinants that could influence the sustainability of pediatric clinical programs. These covariates also help control for other factors at the individual, organization, and intervention level. This is further explained below within the description of mixed-effects modeling.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainability Capacity [CSAT]</td>
<td>Continuous [averaged across 7 domains]</td>
<td>Clinical Sustainability Assessment Tool</td>
</tr>
<tr>
<td><strong>Independent Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality Improvement Score</td>
<td>Continuous [average of 6 questions]</td>
<td>Validation Survey</td>
</tr>
<tr>
<td><strong>Covariates: Individual</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Role</td>
<td>Categorical</td>
<td>Demographics</td>
</tr>
<tr>
<td>Profession</td>
<td>Categorical</td>
<td>Demographics</td>
</tr>
<tr>
<td>Position</td>
<td>Categorical</td>
<td>Demographics</td>
</tr>
<tr>
<td>Service Environment</td>
<td>Categorical</td>
<td>Demographics</td>
</tr>
<tr>
<td><strong>Covariates: Organizational</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization Type</td>
<td>Categorical</td>
<td>Demographics</td>
</tr>
<tr>
<td>Size</td>
<td>Ordinal [3 levels]</td>
<td>Demographics</td>
</tr>
<tr>
<td>Urban/Rural</td>
<td>Categorical</td>
<td>Demographics</td>
</tr>
<tr>
<td><strong>Covariates: Intervention</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of Practice</td>
<td>Ordinal [5 levels]</td>
<td>Validation Survey</td>
</tr>
<tr>
<td>Strength of Evidence</td>
<td>Ordinal [5 levels]</td>
<td>Validation Survey</td>
</tr>
<tr>
<td>Importance</td>
<td>Ordinal [5 levels]</td>
<td>Validation Survey</td>
</tr>
<tr>
<td>Achievability</td>
<td>Ordinal [5 levels]</td>
<td>Validation Survey</td>
</tr>
<tr>
<td>Frequency of Delivery</td>
<td>Ordinal [5 levels]</td>
<td>Validation Survey</td>
</tr>
</tbody>
</table>

Table 3. Variables of interest

**Sustainability capacity**

Sustainability capacity was the main dependent variable for this study. Capacity was represented as the CSAT score for each domain as well as an overall sustainability capacity score. The domain scores were calculated as a simple average of the five subscale items. The total CSAT score was calculated as an average of the seven domain scores. This total score represents the perceived sustainability capacity for the specific clinical setting.

**Quality improvement score**

Six questions were chosen from the Change Process Capability Questionnaire as a proxy for quality improvement work conducted at the site level [83]. This score reflected the overall site relationship to
quality improvement and use of quality improvement strategies. A higher score indicated more experience with and use of quality improvement methods in a certain site.

**Individual covariates**

Four questions were designed to understand characteristics about the individuals that participated. Individuals identified their role on the implementation team, as the team lead, clinical provider, or implementation team member. Participants also reported their profession and position, defined as a bedside clinician or unit leader. Finally, there was a question about the service environment they usually practiced (inpatient vs outpatient).

**Organization covariates**

Individuals identified three things about their organization: the type of organization, size, and location. For this study, all of the sites were large urban settings. However, the type of organization was defined as academic medical center, community setting, ambulatory care, or other types of organization.

**Intervention covariates**

Individuals were asked to assess their perception of the intervention in four different ways. First, people reported the length of time that the intervention had been implemented in their setting. Next, they were asked to identify the strength of evidence supporting the intervention or practice. Third, participants reported their perception of how important the intervention was to provide quality care within their setting. Participants also assessed their perception of how easy the practice was to implement within the
setting, described as achievability. Finally, they were asked about the frequency of delivery, or how many people in their care receive the intervention.

Data Management & Cleaning

The data were recoded, cleaned, and analyzed in R. Both the CSAT scores and a quality improvement score were calculated, derived from the questions taken from the AHRQ Change Process Capability Questionnaire [84]. Initial descriptive and bivariate analyses were conducted before building mixed-effects models.

Individual variables

All four individual-level variables were assessed and three were re-coded to assist with distribution across the data. The participant role remained a categorical variable as collected, with individuals reflecting all types of involvement in the implementation team. The setting was recoded to a binary variable, with individuals identified as those practicing in one setting versus more than one setting (inpatient and outpatient). Due to the frequency of bedside clinicians included in the sample, the other three positions of leadership, administration, and research were collapsed into a single response category. Finally, the individual profession was collapsed into nurses, physicians, and all others (i.e., respiratory therapy, physical therapy, social work, and pharmacists).
Organization variables

Organizational variables were assessed for distribution and some responses were collapsed. Environment was re-coded to a binary variable, assessing those who worked at an academic medical center compared to all other practice settings, such as community hospitals or urgent care. All individuals identified their organization as located in an urban area with a large number of employees, so these two variables were eliminated from the analysis.

Quality improvement

All six questions included in the quality improvement construct were assessed individually and as a scale. One of the six items was re-coded, as it was initially reverse coded. Cronbach’s alpha was calculated to assess the reliability (internal consistency) of the hypothesized quality improvement construct. One item was identified as poor performing and was ultimately removed to create a 5-item scale of quality improvement. The QI scale scores could range from 1 to 5, where higher scores indicated a higher extent of quality improvement capabilities within their setting. This included history of use of quality improvement methods, assessment of quality improvement culture, and strategies that were used in the setting. This scale was utilized in the rest of the study as an average, calculated in the same manner as each of the domains of the Clinical Sustainability Assessment Tool. The value for Cronbach’s alpha for the construct was $\alpha = 0.83$, indicating very good reliability [85].

Multivariate Models

A multilevel analysis was conducted to identify associations of individual-level and contextual factors with clinical sustainability capacity. The study conceptually has three levels of constructs and is illustrated
in Figure 2 below. However, with only three types of programs, a two-level multilevel structure was utilized, where healthcare staff was nested with clinical care sites. Using multilevel analysis helped address clustering and account for contextual information at the organizational level [86].

![Multilevel structure, individuals within sites within programs.](image)

The multilevel modeling equation for this two-level structure was:

\[
\text{Level 1: } Y_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_2 Z_{ij} + r_{ij}
\]

\[
\text{Level 2: } \beta_0 = \gamma_0 + \gamma_{01} W_j + u_{0j}
\]

\[
\beta_1 = \gamma_{10} + \gamma_{11} W_j + u_{1j}
\]

\[
\beta_2 = \gamma_{20} + \gamma_{21} W_j + u_{2j}
\]

In this equation, level one represented the participant level differences in their sustainability capacity score. This was modeled as a function of site-level variables. \( Y \) represented the sustainability outcome in the equation. This was modeled as a function of quality improvement scores measured at the person-level (\( X \)) and other person-level covariates (\( Z \)). The second-level variable, \( W \), included the relevant intervention and site-level covariates (e.g., program type, staff size, etc.). This allowed for a model that can answer one of the main questions of interest requiring a multi-level model, which is how perceived quality improvement predicts sustainability after controlling for other individual and intervention level
characteristics. This model also assisted in answering questions about other relevant determinants of sustainability capacity. This model was built in a block fashion, with intermediate models produced and described below.

**Null model and level 1 variables**

Initially, a null model was tested to fit the intraclass correlation coefficient (ICC). This helps understand the level of variance that is potentially explained by the site-level differences. From there, level one predictors were added to the model. This included the setting in which the participant practiced, the position of the individual, their profession, and the role they had on the team as it relates to the evidence-based practice.

**Model building with level 2 variables**

The creation of the model continued by adding level 2 variables to the model. These included the organization and intervention level variables. These were added in two groups, with the organization variable added first, and then the intervention variables as a group. The organization-level variable added to the model was describing the environment of practice. Finally, the intervention descriptors were added, including the intervention importance, frequency, achievability, length, and strength of evidence. Finally, the QI scale score was added, forming the final model. This block model-building approach allows us to examine the role of QI on sustainability after controlling for the other individual and site-level covariates.

For all models, an ANOVA was run and the AIC parameter was examined to understand the fit and strength of the model to the data, and to allow comparisons of later to earlier models. Additionally, the
models were run for each CSAT domain to understand how these variables might influence particular constructs of sustainability capacity.

**Results**

The data were analyzed in three phases. First, descriptive statistics were generated to assess each individual variable as well as begin to understand sustainability across the programs. Next, bivariate statistical analysis was conducted to understand the relationship between some of these variables and sustainability. Finally, multi-level models were built to answer questions about the relationship of quality improvement to clinical sustainability capacity.

*Describing sustainability across programs* (Research Question 1)

**Participant & setting descriptive statistics**

A total of 181 individuals from three different programs and 30 sites were included in the final analysis. Individual demographics of interest are included in Table 4. Individuals most frequently worked in a single setting (74%) and were involved in direct patient care (70%). About half of the participants were physicians (48%), although all professions were recruited to participate within each setting.
Individuals within the study primarily identified their practice group as pediatrics across all three programs. Participants were also asked to describe their organization size, environment, and evidence-based practice they were assessing (Table 5). Individuals reported their practice environment largely as academic medical centers (84%). Most people described the intervention as existing at their site for less than 5 years and believed the evidence for the intervention to be strong. However, participants demonstrated bimodal reporting for importance, reporting the intervention to be either very unimportant or important. Those participating in antimicrobial stewardship and early mobility reported individuals receiving the intervention more frequently than those in massive transfusion programs. This frequency reporting is consistent with the anticipated frequency of these interventions in clinical settings.
<table>
<thead>
<tr>
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<th>ASP</th>
<th>Mobility</th>
<th>Transfusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 Year</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>1-5 Years</td>
<td>4</td>
<td>73</td>
<td>14</td>
</tr>
<tr>
<td>6-10 Years</td>
<td>15</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>&gt; 10 Years</td>
<td>7</td>
<td>1</td>
<td>10</td>
</tr>
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<table>
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<th>Strength of Evidence</th>
<th>ASP</th>
<th>Mobility</th>
<th>Transfusion</th>
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</thead>
<tbody>
<tr>
<td>Very Weak</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Weak</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Neither weak nor strong</td>
<td>8</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Strong</td>
<td>29</td>
<td>33</td>
<td>15</td>
</tr>
<tr>
<td>Very Strong</td>
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<td>0</td>
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<table>
<thead>
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<th>ASP</th>
<th>Mobility</th>
<th>Transfusion</th>
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</thead>
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</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Neither Important or Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>9</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Important</td>
<td>40</td>
<td>67</td>
<td>36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Achievability of implementation</th>
<th>ASP</th>
<th>Mobility</th>
<th>Transfusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Difficult</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Somewhat Difficult</td>
<td>27</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>Neither Easy nor Difficult</td>
<td>6</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Somewhat Easy</td>
<td>12</td>
<td>29</td>
<td>11</td>
</tr>
<tr>
<td>Very Easy</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of delivery</th>
<th>ASP</th>
<th>Mobility</th>
<th>Transfusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>None of the time</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Some of the time</td>
<td>7</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>Most of the time</td>
<td>24</td>
<td>45</td>
<td>2</td>
</tr>
<tr>
<td>All of the time</td>
<td>19</td>
<td>25</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 5. Intervention level descriptive statistics by program
CSAT scores

Table 6 presents the subscale and overall CSAT scores in total and by each program. The overall CSAT was highest for massive transfusion programs (5.51). Each program had different high-performing domains. The standard deviation suggests there was variability within each of the scores.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>ASP (n = 53)</th>
<th>Mobility (n = 88)</th>
<th>Transfusion (n = 40)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engaged Staff &amp; Leadership</td>
<td>5.21 (1.29)</td>
<td>5.41 (1.14)</td>
<td>5.71 (1.08)</td>
<td>5.43 (1.18)</td>
</tr>
<tr>
<td>Engaged Stakeholders</td>
<td>4.62 (1.19)</td>
<td>5.56 (1.02)</td>
<td>5.26 (1.31)</td>
<td>5.22 (1.20)</td>
</tr>
<tr>
<td>Organizational Readiness</td>
<td>5.13 (1.17)</td>
<td>4.98 (1.17)</td>
<td>5.65 (0.97)</td>
<td>5.40 (1.15)</td>
</tr>
<tr>
<td>Workflow Integration</td>
<td>5.01 (1.17)</td>
<td>5.38 (1.04)</td>
<td>5.6 (0.98)</td>
<td>5.40 (1.09)</td>
</tr>
<tr>
<td>Implementation &amp; Training</td>
<td>4.53 (1.46)</td>
<td>4.84 (1.31)</td>
<td>5.33 (1.22)</td>
<td>5.00 (1.36)</td>
</tr>
<tr>
<td>Monitoring &amp; Evaluation</td>
<td>4.64 (1.58)</td>
<td>4.68 (1.52)</td>
<td>5.31 (1.55)</td>
<td>5.00 (1.56)</td>
</tr>
<tr>
<td>Outcomes &amp; Effectiveness</td>
<td>5.46 (1.21)</td>
<td>5.93 (0.89)</td>
<td>5.60 (0.91)</td>
<td>6.00 (1.02)</td>
</tr>
<tr>
<td>Total Score</td>
<td>4.91 (1.07)</td>
<td>5.25 (0.92)</td>
<td>5.51 (0.91)</td>
<td>5.20 (0.98)</td>
</tr>
</tbody>
</table>

Table 6. CSAT subscale and total score by program presented as Mean (SD)

Figure 3 depicts the CSAT scores based on program type illustrates the variation by program across each of the domains. Transfusion programs had higher scores in five of the domains, with the mobility programs having the highest domain averages in the other two.
Quality improvement scores

This domain was calculated utilizing the average of the five items that were included after calculating Cronbach’s alpha. Table 7 presents the item and scale averages and standard deviation for each practice as well as overall. The lowest item mean was regarding quality improvement in the past year and the highest was related to using quality improvement skills. The antimicrobial stewardship and transfusion programs had the highest overall QI scores, with antimicrobial stewardship programs being slightly higher. Like with CSAT scores, the standard deviation indicates there was variability within the QI scores.
<table>
<thead>
<tr>
<th>Question</th>
<th>ASP</th>
<th>Mobility</th>
<th>Transfusion</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our clinical team understands and uses quality improvement skills effectively.</td>
<td>4.43 (0.69)</td>
<td>4.18 (0.77)</td>
<td>4.35 (0.80)</td>
<td>4.29 (0.76)</td>
</tr>
<tr>
<td>Our clinical team has changed or created systems in the organization that make it easier to provide high quality care.</td>
<td>4.40 (0.69)</td>
<td>4.16 (0.83)</td>
<td>4.33 (0.83)</td>
<td>4.27 (0.79)</td>
</tr>
<tr>
<td>We choose new processes of care that are more advantageous than the old to everyone involved (patients, clinicians, and our entire clinical team).</td>
<td>4.06 (0.79)</td>
<td>3.93 (0.80)</td>
<td>4.23 (0.86)</td>
<td>4.03 (0.82)</td>
</tr>
<tr>
<td>The working environment in our clinical team is collaborative and cohesive, with shared sense of purpose, cooperation, and willingness to contribute to the common good.</td>
<td>4.25 (0.87)</td>
<td>4.13 (0.84)</td>
<td>4.30 (0.76)</td>
<td>4.20 (0.83)</td>
</tr>
<tr>
<td>Our clinical team has greatly improved quality of care in the past year.</td>
<td>4.11 (0.75)</td>
<td>3.91 (0.79)</td>
<td>4.00 (0.75)</td>
<td>3.99 (0.77)</td>
</tr>
</tbody>
</table>

| Total Score | 4.25 (0.55) | 4.06 (0.61) | 4.24 (0.67) | 4.16 (0.61) |

Table 7. Quality improvement items from Change Process Capability Questionnaire

Associations of Intervention Characteristics and Clinical Sustainability (Research Question 1)

After assessing univariate distributions, we evaluated bivariate associations between the intervention variables and the outcome of the total CSAT score. The five intervention variables assessed were: (1) achievability, operationalized as the perceived ease of implementation in the clinical setting, (2) length, or how long it has been implemented, (3) strength of evidence of the practice, (4) frequency, or how often the intervention was utilized in the clinical setting, and (5) importance, or how important the intervention is within the clinical setting. Length of practice (Figure 4) was variable across sites and illustrated that there were responses for sites of different lengths of implementation.

Respondents reported that the interventions had a moderate to strong evidence base, and higher ratings of strength were associated with higher CSAT scores (Figure 5). No one reported that the intervention was
delivered to every individual within their practice setting, but nearly everyone reported that it was delivered to some people (Figure 6). Generally, individuals were neutral about achievability or believed that their interventions were difficult to achieve (Figure 7). While individuals believed the strength of evidence to be relatively strong, importance was usually rated at one extreme or the other. Individuals seemed to have a definitive perception about the importance, although this did not have a positive correlation with CSAT Total score (Figure 8).

Figure 4. Total CSAT score by length of practice.
Figure 5. Higher perception of evidence strength increased CSAT total.

Figure 6. CSAT Total Score distributed by frequency of intervention delivery.
Figure 7. CSAT total score by achievability of implementation.

Figure 8. CSAT total by intervention perceived importance.
**Model Relationships Between Individual, Site-level, and Quality Improvement Covariates with Clinical Sustainability (Research Question 2)**

After assessing both univariate and bivariate statistics, multilevel mixed-effects modeling was conducted. The models are summarized in Table 8. Four models are presented, starting with a null model (no covariates), an initial substantive model with individual-level covariates, a multilevel model with both individual and site-level covariates, and then a final model with QI scores. The parameters that were significant at p<.05 are bolded.

**Null model**

The ICC calculated from the null model was 0.12, indicating some variability that is accounted for by the different sites. This non-zero value supports the approach of using mixed-effects modeling to account for clustering of individual-level scores within the specific sites [86].

**Model with level 1 variables**

All level one variables were added to the model at the same time. While the level one variables enhanced the model, only one was a significant predictor of sustainability scores within the three programs. Individuals who identified as being primarily in positions other than bedside providers perceived higher sustainability capacity.
Model with level 2 variables

Level two variables were added in two phases to the model. First, organizational variables of program and environment were added. Subsequently, the intervention characteristics were added. The AIC suggested that these variables improved the model, although few were significant. The transfusion program staff reported higher CSAT scores relative to the ASP programs. Higher perception of strength of evidence for a program also resulted in higher CSAT scores. Individuals that reported higher frequency of delivery, meaning the intervention was delivered more frequently, also reported higher overall CSAT scores. However, the perceived ease of implementation and length of time in practice did not significantly impact the overall CSAT score.

Final model (QI variable)

Finally, the five-item quality improvement construct was added to the overall model. The AIC decrease suggests that the model was improved through the addition of this construct. This variable was also significant, suggesting that stronger quality improvement systems within the hospital are associated with greater overall sustainability capacity. In this model, intervention frequency, the strength of evidence, and transfusion program remained significant. These results show that after controlling for the person and setting level variables, we find that perceptions of higher QI are significantly related to overall clinical sustainability scores. This final model is a significant improvement over the level-2 model (LR Chi-square = 38.9, \(p < .01\)). The AIC also indicates that this final model is the best fit to the observed data (lower AIC values indicate better fit).
<table>
<thead>
<tr>
<th></th>
<th>Null Model</th>
<th>Level 1 (person) Variables</th>
<th>Level 2 (setting) Variables</th>
<th>Final Model with QI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>SE</td>
<td>Coef.</td>
<td>SE</td>
</tr>
<tr>
<td>Intercept</td>
<td>5.15</td>
<td>0.10</td>
<td>4.91</td>
<td>0.25</td>
</tr>
<tr>
<td>Setting (Reference: Single)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setting: Multiple</td>
<td>0.12</td>
<td>0.18</td>
<td>0.04</td>
<td>0.17</td>
</tr>
<tr>
<td>Position (Reference: Bedside)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position: Other</td>
<td>0.40</td>
<td>0.19</td>
<td>0.19</td>
<td>0.18</td>
</tr>
<tr>
<td>Profession (Reference: Nurse)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profession: Physician</td>
<td>0.09</td>
<td>0.22</td>
<td>0.30</td>
<td>0.21</td>
</tr>
<tr>
<td>Profession: Other</td>
<td>0.15</td>
<td>0.23</td>
<td>0.36</td>
<td>0.22</td>
</tr>
<tr>
<td>Role (Reference: Team Leader)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Role: Administration</td>
<td>0.05</td>
<td>0.30</td>
<td>0.13</td>
<td>0.28</td>
</tr>
<tr>
<td>Role: Participating</td>
<td>-0.07</td>
<td>0.20</td>
<td>0.00</td>
<td>0.18</td>
</tr>
<tr>
<td>Role: Evaluator</td>
<td>-0.46</td>
<td>0.44</td>
<td>-0.45</td>
<td>0.39</td>
</tr>
<tr>
<td>Role: Clinical staff</td>
<td>-0.04</td>
<td>0.19</td>
<td>-0.12</td>
<td>0.19</td>
</tr>
<tr>
<td>Program (Reference: Stewardship)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program: Early Mobility</td>
<td>0.33</td>
<td>0.23</td>
<td>0.37</td>
<td>0.19</td>
</tr>
<tr>
<td>Program: Transfusion</td>
<td>0.64</td>
<td>0.23</td>
<td>0.65</td>
<td>0.19</td>
</tr>
<tr>
<td>Environment (Reference: Academic Center)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment: Other</td>
<td>0.14</td>
<td>0.21</td>
<td>0.11</td>
<td>0.19</td>
</tr>
<tr>
<td>Int. Importance (Reference: Not important)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Int. Importance: Important</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Int. Importance: Very important</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention: Strength of Evidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention: Length of Implementation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention: Achievability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention: Frequency of Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality Improvement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model Fit</td>
<td></td>
<td>AIC 509.7</td>
<td>AIC 471.0</td>
<td>AIC 434.1</td>
</tr>
<tr>
<td>Model Improvement (LR Chi-squared)</td>
<td></td>
<td>56.7 (p &lt; 0.01)</td>
<td>38.9 (p &lt; 0.01)</td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Final models with individual, intervention, and organizational predictors. (Bolded parameters indicate significance at p < .05)
How Quality Improvement Influences Sustainability Capacity

After the final model was completed and assessed, further analyses were conducted to understand more about the direction and strength of the relationship between quality improvement score and CSAT total score. Figure 9 shows the relationship between total QI score and total CSAT scores. There is a moderately strong, positive association between these two variables ($r = 0.49$, $p < .001$). This reinforces the general finding that an increase in QI is associated with higher CSAT scores. As shown above in Table 8, this positive relationship persists even after controlling for a wide variety of individual and setting-level characteristics.

Figure 9. Relationship between QI Total Score and Total CSAT Score, showing moderate positive correlation
To understand how quality was operating through the sustainability score, the entire model was run with each of the seven CSAT subscale scores as the dependent variable. The final model with all covariates was run, and the parameter estimates for the QI variable for each of the seven models are presented in Table 9 (see Appendix C for the full model results). Quality improvement was significantly associate with CSAT subscale scores for every domain. Quality improvement functioned most strongly through monitoring and evaluation and organizational readiness and least through engaged stakeholders and outcomes and effectiveness. However, an increase in quality improvement scores led to a significant increase in CSAT domain scores in all of the seven domains.

<table>
<thead>
<tr>
<th>CSAT Domain</th>
<th>Quality Improvement variable in final model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
</tr>
<tr>
<td>Engaged Stakeholders</td>
<td>0.38</td>
</tr>
<tr>
<td>Outcomes &amp; Effectiveness</td>
<td>0.43</td>
</tr>
<tr>
<td>Engaged Staff &amp; Leadership</td>
<td>0.49</td>
</tr>
<tr>
<td>Workflow Integration</td>
<td>0.64</td>
</tr>
<tr>
<td>Implementation &amp; Training</td>
<td>0.70</td>
</tr>
<tr>
<td>Organizational Readiness</td>
<td>0.87</td>
</tr>
<tr>
<td>Monitoring &amp; Evaluation</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Table 9. Mixed effect models for each subdomain, focused on QI variable. (All parameters were significant at p < .05).

**Discussion**

*Sustainability and Quality in Pediatric Hospital Care*

This study assessed the relationship of various individual and organizational constructs to sustainability scores. Our work suggests that quality improvement capability within the hospital is related to the capacity to sustain evidence-based practices after implementation. The construct of quality improvement is
especially important in pediatric hospital care due to its unique and extensive engagement with the field of quality.

In the final model, individual-level variables were not found to be predictive of overall sustainability capacity. However, an individual’s position on the clinical team influenced their perception of sustainability in the level one model. This suggests that bedside providers have different perceptions of sustainability scores, and builds on other studies suggesting that the role of the provider is important when thinking about the implementation of new practices [87, 88].

Various factors related to the intervention were significantly related to higher sustainability capacity. When the program level variables were added, increases in perceived strength of evidence and frequency of delivery resulted in higher sustainability scores. The results suggest that how an individual perceives the evidence base of a practice is important, as it increases the likelihood the intervention will be sustained. Second, the frequency of delivery suggests that the more people in a unit receive an intervention, the greater likelihood that the capacity remains high. This could potentially function through the idea of workflow integration and is supported by other literature highlighting the importance of routinization into the workflow [30, 89]. However, it is important to consider how to sustain interventions that might be high acuity and occur less frequently. While this applies to the transfusion practice in this study, it could apply to other settings such as resuscitation and stroke care.

Transfusion programs had significantly higher ratings of clinical sustainability when compared to antimicrobial perioperative prescribing. This is especially interesting given that antimicrobial prescribing is a higher frequency intervention, where transfusion protocol activation is a rare, although serious, event. This difference was true after controlling for frequency of delivery and other intervention level characteristics, which suggests that there are other factors about the intervention that need to be assessed
and characterized in future work. Since this was the first study comparing these three interventions, there is no prior taxonomy for describing the potential differences that were seen in this analysis.

While the length of implementation has been used as a proxy for sustainability, this study suggests that there is no relationship between the length of implementation and capacity for sustainability. This would require a shift in emphasis from a time-based measure of sustainability to more focus on other contextual and organizational influences.

Finally, the measure of quality improvement capability within the hospital was found to be related to overall sustainability capacity. After controlling for everything else, quality improvement helps understand how sustainability works within clinical settings. This emphasis on organizational readiness and conditions that enable healthcare teams to focus on quality care translates to teams and organizations that continue to provide evidence-based interventions to their patients. This descriptive study responds to foundational calls within the field of sustainability and is consistent with literature focusing on bridging factors or enabling conditions that help move organizations into these high-performing teams for consistent, ongoing evidence-based care delivery [53, 90].

**Advancing Sustainability Measurement**

Our findings rely on the use of the Clinical Sustainability Assessment tool. The CSAT scores were consistent, regardless of individual-level characteristics. While this is a surprising finding, it is likely good that the CSAT scores are not predicted by these individual-level variables. While advancing knowledge about sustainability within pediatric hospital systems, this study also develops the study of sustainability. There have been consistent calls for measurement to advance the understanding of sustainability and sustainment. The CSAT has demonstrated initial reliability and remains valid as it is utilized in different
care settings. Therefore, this tool advances the pragmatic measurement of sustainability and moves toward future work that is theoretically driven and can predict determinants of sustainability. This work further reinforces some of the frameworks that address sustainability as a dynamic concept. Taking all of this together, it suggests that future studies should be focused on the organization and intervention level determinants of sustainability, including the factors that connect to stakeholder behavior.

_Implementation Science and Quality Improvement_

Ultimately, this work also responds to a theoretical question that has been posed within improvement sciences about the relationship between implementation science and quality improvement. This project finds alignment between the two fields in the areas of organizational design, process, and evaluation. Easterling et al. found implementation science and quality improvement literature to be separate bodies of work when they were assessing learning health system literature [90]. In other literature, quality improvement is described in the ways that the science provides tools and theories to assist in rapid improvement when necessary at a local level [13]. Implementation science has a broader conceptual understanding, due to researchers and practitioners within the field focusing on the process for change, context alignment, and outcomes related to both implementation outcomes as well as patient health [91-93]. Perhaps all of this is best understood within the frame of something else, such as learning health systems. This would only work if it allowed for the synthesis of the other improvement sciences within clinical healthcare, resulting in a blend of simultaneous research and application with a full understanding of context and process. This would allow both researchers and practitioners interested in healthcare improvement to build better designs, causal arguments, and practical understanding of how to create lasting change.
Chapter 3: From Frontline Clinicians: Expanding
on Relevant Constructs for Sustainability and
Their Validity for Clinical Practice
Background

Sustainability

Sustainability is used to describe how programs, organizations, interventions, and behavior changes continue over time [8, 17, 94]. There has been a consistent increase in attention paid to sustainability and work targeted at developing models and measures to understand the construct within a variety of contexts [7, 8]. Literature within the field of implementation science has clarified numerous aspects of sustainability, including sustainment vs sustainability and the role of sustainability capacity. Most generally, sustainability has been described as the “extent to which an evidence-based intervention can deliver its intended benefits over an extended period of time” [95]. More specifically, sustainability capacity has been defined as “the existence of structures and processes that allow a program to… maintain evidence-based policies and activities” [32, 38]. Finally, sustainment is explained as the “continued enactment of processes, practices, or work routines that are conveyed and learned through an intervention” [27, 31]. These elements are critical to programs and interventions for maximal patient outcomes and public benefit to be realized through evidenced-based implementation efforts.

Sustainability capacity, therefore, is a necessary precursor to sustainability and sustainment within individuals, teams, organizations, and systems. The determinants of sustainability capacity have been broadly described in terms of individual factors (stakeholders, relationships), processes, and organizational elements that enable a program to continue to be delivered appropriately.

Sustainability in Clinical Healthcare

Unique factors about clinical healthcare delivery have led to research specifically focused on sustainability within healthcare settings and systems. The Clinical Sustainability framework and assessment tool was
developed based on the understanding that clinical delivery settings differed enough from other public health contexts to warrant a separate framework [36, 37]. The public health framework relies more heavily on external funding and policy, while the clinical framework has a greater focus on workflow processes and individual stakeholders that are involved in care delivery.

Clinical contexts have been studied in various realms of implementation science. Cancer care delivery has certainly driven a lot of implementation science development [96]. This body of literature has highlighted some of the ways that clinical settings are different, including finances, processes, and the roles of clinicians, middle managers, and upper administration. Therefore, clinical settings require special attention to understand how healthcare is being delivered to all individuals. In order to reach full impact, it is vital that the research remains relevant to the clinical context.

Sustainability within clinical healthcare has had some conceptual development, although there is still no consistent definition. Some measurement work has been done, with a few measurement tools that have been developed [36, 97, 98]. The Sustainment Measurement System Scale [98] was developed specifically for behavioral and mental health, while the NIH Sustainability Model [97] and the Clinical Sustainability Assessment Tool [36] focus more broadly on all clinical contexts. The Clinical Sustainability Assessment tool (CSAT) is still being utilized in a variety of contexts for sustainability measurement in clinical care [99]. While some validity data was collected in the development of the CSAT, there is need for more validity work, such as across different settings, context, and participant perspectives.

*Importance of the Frontline Clinician*

Although there has been a lot of focus on the role that leadership play in knowledge translation, clinicians directly engaged in the practice are uniquely positioned to influence healthcare delivery at the bedside. It
remains unclear how different professions might have different perspectives, such as differences between physicians and nurses and other allied healthcare team members. In studies that have engaged healthcare settings to understand sustainability, the participants have often been managers, administration, or others that would be considered leadership. Urquhart and colleagues conducted one study focused on the role of middle management in the ultimate implementation of evidence-based care [100]. While it was positive that these influences were similar to the determinants of sustainability capacity, this does not include the perceptions of bedside providers. Similarly, other qualitative work to define sustainability and identify relevant factors has also been conducted with those seen as leaders within the program or intervention [101, 102].

However, it is frontline clinical providers are often responsible for the day-to-day execution of new practice implementation, monitoring, and sustainment. Therefore, their views and experiences are critically important to build a deeper understanding of organizational capacity for clinical sustainability. Additionally, these clinicians are in a unique position to prioritize certain interventions and develop a clinical environment that enables high-quality care. There is very little understanding of how clinicians perceive sustainability and their ability to shape sustainment. One study, conducted by Colon-Emeric et al., interviewed both staff and managers separately regarding the sustainment of evidence-based practice in long-term care settings [103]. This study did highlight differences in staff and management perception of relevant factors, further emphasizing the need to explore sustainability capacity within all levels of staff and clinicians within clinical care settings.

The main goal of this study is to explore the perspectives and experiences of clinical frontline staff, to enrich our understanding of clinical sustainability, and to further validate the constructs in the clinical sustainability framework.
Theoretical Framework

Two frameworks were utilized in the design and analysis of this study. Implementation science uses five different categories of conceptual approaches, but this study focuses on determinant frameworks [104]. Determinant frameworks focus on the constructs, or barriers and enablers, that influence implementation outcomes [104]. These determinants are reflected in the conceptualization of sustainability capacity. Conceptually, scholars within the field have focused on capacity building with the assumption that the organizational context, comprised of people, teams, and systems, can improve through strategic planning and sustained work. This context translates to increased uptake and use of evidence-based practice, which ultimately improves patient outcomes and system functioning, as initially made explicit by Proctor and colleagues [20]. This conceptual underpinning is reflected similarly in both frameworks that inform this study, the CSAT framework (Figure 10) and the Exploration, Preparation, Implementation, Sustainment (EPIS) model (Figure 11).
Figure 10. The CSAT Framework

Figure 11. The Exploration, Preparation, Implementation, Sustainment framework [52, 54]
The CSAT framework (Figure 10) consists of seven domains that are relevant to clinical sustainability capacity [36]. Clinical sustainability capacity is, in turn, hypothesized to predict downstream sustainment outcomes. The seven capacity domains are: (1) engaged staff and leadership, (2) engaged stakeholders, (3) organizational readiness, (4) workflow integration, (5) implementation and training, (6) monitoring and evaluation, and (7) outcomes and effectiveness [29, 36]. Each of these domains is seen as being distinctive, although interrelated, and may exist to various extents within different clinical settings. These also may change over time as a result of internal or external forces. Sites that have a larger total amount of each of these are better positioned to be able to sustain evidence-based care delivery over time.

The Exploration, Preparation, Implementation, Sustainment (EPIS) framework includes both process and determinants. While the overall model includes this process of implementation, the focus for this study was on the conceptualization within the model of determinants. The model includes factors within a system that enable the implementation process to occur. While the framework does not specifically identify sustainability capacity, CSAT domains are reflected in elements that exist both in the inner and outer context of EPIS. The outer context is described in the framework as that outside of the organization. However, for healthcare programs, units, and teams such as those included in this study, the outer context is often the larger hospital organization or system. The inner context would refer to the factors within the team, program, or medical unit. This model primarily informed the work through its recognition of intervention (evidence-based practice) and bridging factors that exist between the inner and outer context. Therefore, some factors create an interaction between the domains of the CSAT that must be recognized and studied in addition to the domains themselves.

When developing the interview guide, the constructs within the CSAT framework were used to inform areas of inquiry. The EPIS framework was also used to inform questions about the nature of the
intervention and the differentiation between how the inner and outer context influences decision making for frontline providers. Further, these two frameworks were utilized to develop the codes for initial analysis. Where there was explicit overlap between the CSAT domains and EPIS constructs (e.g., monitoring, processes, leadership), they were grouped together as one determinant.

**Qualitative Methods in Implementation Science**

Traditionally, models for research in healthcare have drawn from positivist and post-positivist approaches, relying heavily on quantitative analysis and experimental design. However, implementation science’s strong foundations in social science traditions brings more awareness and acceptance of interpretive frameworks and associated research designs. Implementation science also relies heavily on the use of models, frameworks, and theories to further research design as well as offer a paradigm for interpretation and generalization [14]. Thus, the emergence of mixed methods as a prominent research design for hospital-based implementation science is a logical synthesis given this history.

Interpretive work has been used to inform implementation science in a variety of ways [14, 105, 106]. First, the use of qualitative analysis has furthered the understanding of measurement and been used as a way to both define and validate outcomes for the field. Second, qualitative analysis is used as a way to understand contexts of different healthcare units and teams, most specifically as a way to understand barriers to uptake of interventions and practice change.

Both qualitative and quantitative methods have been utilized to assist in understanding the measurement of fidelity and how to validate measures to understand this construct [107, 108]. The measures themselves still have psychometric properties and are rooted in quantitative analysis, but the analysis of the measure and process of defining the construct occurs through the use of qualitative methodology. Keith *et al.*
conducted semi-structured interviews to enhance their theory and methodology about the measurement of fidelity of interventions within clinical contexts [107].

The second way qualitative work has entered the hospital implementation world is within the understanding of culture, or context. Often, this understanding is created by using interviews or focus groups to understand barriers and facilitators as well as the capacity to implement within a given healthcare team [109, 110]. Most qualitative work presented provides a rich, specific description but stops short of generation of theory.

To advance the rigor, usefulness, and reporting of interpretive methodologies, *Implementation Science* released a supplement in January of 2018 focused on the synthesis of qualitative work within the field [111]. This supplement aims to advance understanding and usefulness of qualitative work while addressing topics such as bias, relevance, and adequacy of data. This supplement helped establish interpretive paradigms as a major methodology for the implementation science field broadly.

Prior use of qualitative methods within implementation science informs the design of this study. Additionally, qualitative methodology was fitting for these research question for a few reasons. This study asks questions about the perspectives of frontline staff. Additionally, this work is focused on describing clinical context. Taking an interpretive approach is most appropriate for answering the questions set out in this study, which is similar to prior qualitative work within implementation science research.

*Objectives*

The current study will explore the clinician experience and individual roles contributing to sustained pediatric clinical programs. Additionally, it will investigate clinician perceptions of relevant clinical sustainability domains within these programs. It will answer the following questions:
(1) In what ways do frontline clinicians think about sustainability (i.e., perceptions and beliefs) within their clinical care settings?

(2) How do frontline clinicians understand the constructs that contribute to sustainability?

(3) What are the roles that clinical staff have in the sustainment of evidence-based practices?

The results of this study will allow for a greater understanding of how sustainability measurement reflects the clinical setting and ensure that the constructs are valid within clinical care.

**Methods**

To answer the study questions outlined above, a qualitative research design was used. One-on-one interviews were conducted with diverse groups of frontline staff in three clinical programs. Deductive and inductive coding followed by thematic analysis was conducted.

*Interview Guide Development*

Before creating an interview guide, a review of literature in the area of sustainability was conducted. After considering the gap of foundational studies regarding sustainability and its determinants as perceived by frontline clinicians, an initial list of questions was drafted. The questions were reviewed and edited by clinicians, implementation scientists, and qualitative experts (Jason Newland, Enola Proctor, Ross Brownson, Douglas Luke, Beth Prusaczyk, Virginia McKay, Sapna Kudchadkar, and Dylan Graetz). The final interview guide (Appendix C) consisted of two sections: (1) the individual experience of sustainability in the clinical setting and (2) the constructs contributing to clinical sustainability (i.e.,
potential determinants). The interview was pilot tested with a pediatric clinician prior to full enrollment. 
After pilot testing, the questions were refined and the order of the topics were changed to improve the interview. This resulted in a final interview guide that was used for the duration of the study (Appendix C). The study was approved by Washington University in St. Louis Institutional Review Board (#202102017).

Participants

This study was conducted amongst individuals who had participated in a prior study where they completed the Clinical Sustainability Assessment Tool (CSAT) (see chapter 2). Individuals were clinicians who were delivering one of three practices at their pediatric hospital: (1) antimicrobial stewardship in perioperative surgery, (2) early mobility in the intensive care unit, or (3) massive transfusion blood delivery. Individuals were eligible to participate in this qualitative interview study if they were directly involved in care delivery.

Purposeful sampling was used to ensure there was representation from all three programs as well as both physician and non-physician clinicians. Non-physician clinicians included nurses, respiratory therapists, pharmacists, physical therapists, and blood bankers. Thirty frontline clinicians participated in interviews. There were 13 physician and 17 non-physician participants. Non-physician clinicians consisted of pharmacists, therapy services, and blood bank lab members. Individuals were sampled from each of the three programs of interest. All participants were affiliated with academic medical centers. Recruitment was stopped when two criteria were met: (1) individuals from each program and profession were recruited and (2) saturation was reached.
**Data Collection**

SM sent emails to potential participants to request participation in a semi-structured interview, conducted over teleconferencing software. If participants agreed, they were interviewed over Zoom or Teams at scheduled times.

SM conducted in-depth interviews with 31 individuals at pediatric academic medical centers. Individuals were involved in one of three programs of interest: early mobilization, massive transfusion, or antimicrobial stewardship. The interview focused on how clinicians view sustainability in their work settings. This focused on their perceptions of actual sustainability outcomes as opposed to future potential or theoretical outcomes [112, 113]. Interviews were utilized to ask complex questions and allow respondents of different hierarchies the freedom to discuss their opinions and experiences. Consent was obtained before the start of the interview and individuals were compensated with a gift card after the interview. All interviews were successfully completed. Each interview lasted on average 30-45 minutes and was conducted by SM. The interviews were audio-recorded.

**Analysis**

Audio recordings for each interview were transcribed using an online transcription service. Each transcription was de-identified by SM. Transcripts were then reviewed for accuracy using the original recordings. The transcripts were uploaded and analyzed in NVivo v11. A deductive content analysis was used for initial coding. SM developed a codebook (Appendix D) that identified and defined codes informed by the Clinical Sustainability Assessment Tool and EPIS framework. This facilitated an analysis that was relevant to the contextual areas of inquiry. SM coded the transcripts following the assigned
codebook and participated in peer debriefing throughout the coding process [114, 115]. Following completion of coding, thematic analysis was used as outlined by Saldaña [116].

Results

Participants

Thirty professionals across the three programs participated in the interviews. There were 13 physicians and 17 non-MD clinicians that participated. There were also individuals across multiple disciplines that were involved in each program. Within the stewardship practice, there were infectious disease physicians, surgeons, and pharmacists. In the early mobility programs, there were physicians, physical and occupational therapists, nurses, and respiratory therapists. Finally, in the transfusion practice, there were surgeons, critical care physicians, nurses, and blood bankers.

Coding

The data were originally coded using the codebook developed. Each of the codes were used in the coding process and only codes developed a priori were used. The codes for monitoring and evaluation, engaged stakeholders, and engaged staff and leadership were the three most common codes used. There was also robust discussion about the electronic medical record and other strategies that were coded both as bridging factors and workflow integration. People described interventions that had sustained as well as those that had ceased to exist within their setting. Overall, most of the transcripts after the initial rapport building and introductory questions were able to be coded and informed the themes that were identified in the study. Table 10 describes the major codes informing each theme. While thematic analysis followed the steps described above, there are codes that align with the themes.
Five themes emerged from the thematic analysis as important to consider for clinical sustainability: (1) importance of ensuring sustainability, (2) influence of social relationships and engagement, (3) reactionary, clinician-reliant efforts (4) impact of larger organization and systems, (5) limited consideration of finances. Table 11 presents all five themes and representative quotes. All five themes
were discussed in interviews of individuals from each of the three programs as well as amongst different professions.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Example statements</th>
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| **Clinicians consider sustainability - often only after initial implementation** | • “For our program, we've been talking a lot about sustainability.” - Nurse  
• “I think planning it initially that it's about getting it started, but I do feel like we're good about once they actually get started, OK, now that we got it started how are we gonna keep it going?” – Nurse  
• “so that has actually been pretty nicely sustained because we still run that report is part of our audit and feedback grounds  
• “I would love to say yes, we have the foresight to... So that's the goal. But honestly with all the work that it takes to get something rolled out and get all the stakeholders involved. We just want to like, at that point we're just like, let's just go and see if something is broken.” - Pharmacist |
| **Social relationships support sustainability** | • “[Intervention] in the end is a social game. It's actually more about the social than it is about the medicine. The medicine is the medicine ...so it does, it comes down to more of the behavioral change and the communication and social factors, and if one thinks that they can get it changed through email, or electronic health records, man, I’d like to find that person. And if they said they were successful, I probably wouldn't even believe them.” – Physician  
• “You have to have bedside leaders of it. You have to have ‘people that are doing it’ leadership. And I mean, buy-in by your staff is the most important part.” – Respiratory Therapy  
• “The relationship business of this is bar none what will keep something afloat, even if everything is on fire… Approachability I think is key in sustainability, because if you have a question or you have a need and you're not able or feel comfortable to share it, then it's just not going to happen. So, I think that relationships are huge in that.” – Physical Therapy |
| **Sustainability strategies are often reactionary and clinician-reliant** | • “That's one of the things that we could do, probably a little bit better, is we don't usually have a plan for like next checkpoints…so what ends up happening is that we have like a twice weekly meeting where we just check in on the many things that we're doing, and if there's like a fire to be put out, then we deal with that fire.” - Physician  
• “We have like a laminated little spreadsheet, that kind of helps us remember everything we're supposed to do for the day. We have electronic documentation that helps us remember, and then we also… put papers outside of each room door… and it's kind of just remind you what they need to be doing.” - Nurse |
Clinicians consider sustainability after initial implementation

Bedside clinicians were able to discuss the importance of sustainability of evidence-based practices within their unit and could quickly identify times that programs had sustained or failed to sustain, which aligned with the concept of achieved outcomes [112]. These care team members described the construct as one that was relevant to them in the clinical setting. When asking about designing for sustainability, it was...
often talked about as a second project or a different phase than the initial implementation. However, the acknowledgment of it often came with discussing the places where sustainability either (1) fell short or (2) presented a huge work burden.

Social relationships support sustainability

Every interview highlighted the importance of clinicians, stakeholders, and social relationships within the clinical team(s). All professions discussed the importance of having high-quality relationships and how that social climate could ultimately impact clinical decision-making. While individuals spoke about champions for an initiative and their influence, the need was also recognized to have bedside providers that engaged in the initiative. This development of buy-in through social capital was the primary concept that clinicians discussed regarding culture and climate to promote ongoing evidence-based care in the clinical environment.

Sustainability strategies are often reactionary and clinician-reliant

During the course of the interviews, clinicians discussed the strategies that their teams had utilized to increase the potential to sustain evidence-based practices. When initially rolling out the practice change, these strategies are not always initially planned for and enacted. A lot of the strategies that were ultimately used involved data extraction or auditing and feeding the information back to clinicians about deviance from desired behavior. These efforts were described as burdensome to those who were tasked with conducting the audit. There was concern that if the individual who was responsible for the sustainability of the practice were no longer involved, the maintenance of the practice would subsequently end. Some
programs or units have hired individuals specifically to conduct these interventions to help with the continuing use of the practice.

**Organization and system changes have a large impact on clinical team sustainability**

When considering other influences to the sustainability of programs, there was a pattern in the conversation about different structural and process influences that existed outside of the immediate team or unit. For example, individuals discussed the role of the medical record and how teams create order sets or best practice reminders to influence decision-making behaviors. These were discussed as useful, but clinicians also acknowledged the frequency that they get ignored or forgotten by those at the bedside responsible for delivering the intervention.

Some individuals discussed the frustration surrounding policies and organization changes that happen ‘house-wide’, or at the entire organization level. These often had what were described as unintended consequences that created barriers to the sustainability of their initiatives. Other times, the necessity to go outside one individual team and understand the entire process or interactions between different teams was described as essential to continued practice delivery.

**Clinicians describe limited consideration of finances**

When talking about things that did and did not influence sustainability, clinicians stated that they did not think about money. It often did not come up at all until near the end of the interview when it was brought up in the interview guide. Some clinicians explained that they do not have control over budget spending and the structure of care delivery means that they do not require these specific budget lines to implement or continue an intervention or to ensure the evidence-based practice occurs. When talking about money, it
was described as a way of hiring additional individuals to be involved, not as it related to budgets for programmatic delivery. Personnel resources were mostly described as staff time in the form of full-time effort or having the time to dedicate to the program or practice. Due to this, people usually think about how to add the necessary work and duties into a previously existing structure or role within the unit as opposed to finding new staff effort.

*Other Findings*

**Profession vs role differences**

Initially, stratification for the sample was due to anticipated differences for physicians and other professions when discussing clinical sustainability. However, there were no major differences between how physicians and other multi-professional team members spoke about sustainability and the determinants for sustaining evidence-based interventions. Both groups discussed multi-level and multi-professional factors that influence how programs continue to be delivered in their setting.

There were differences in the discussion based on the individual’s role affiliated with the implementation effort. For instance, those who were responsible for the auditing talked about sustainability differently than those who only interfaced with the intervention through bedside delivery. Those who felt personal responsibility talked in much more detail about the nuances of integrating the intervention into the workflow, the struggles with maintaining buy-in, and the process elements of the intervention.

**CSAT domains**

As stated above, the CSAT domains were discussed throughout the interviews. When beginning to discuss these constructs, the interviewer simply asked the participant what they perceived as important for
sustainability. The first answer in nearly every interview was the discussion about buy-in from other clinicians. While the CSAT uses the idea of inner setting staff or external stakeholders, clinicians often describe this as their immediate team (inner setting staff) and then consultants or other teams (external stakeholders. The programs had different amounts of engagement with external stakeholders, but it was clear that those who influence the delivery of care were considered the most important. For the ASPs, this included the individuals within the healthcare setting that prescribed antibiotics. For mobility programs, this was often the nurses or therapy services team members that were responsible for getting patients up and moving. Transfusion programs seem to span more programs, with discussion more focused on external stakeholders or the interactions between many different teams. The conversation was often about the acts of convincing other stakeholders that the intervention is important and worth spending time to deliver. These stakeholders included individuals in other units, affiliated teams, or others who had the power to decide if the practice should be delivered to a patient.

Transfusion team members spent the most time discussing the workflow integration that they had to consider. While all three programs acknowledged the electronic medical record, the transfusion programs also talked about other workflow aids. These included things like coolers, specific types of supplies, and the location of necessary components. Part of this discussion was in acknowledgement of the speed at which this intervention must be delivered in order to be successful. As indicated, all programs did discuss the use of order sets and reminders within the electronic medical record. The medical record was described as useful only if individuals happen to be interfacing with it, but there were often scenarios described where it was ignored or not immediately available while individuals were at the bedside.

The other domain that individuals often brought up on their own was monitoring and evaluation. Clinicians described that this relied on an individual, as mentioned above. Often, this involved multiple reminders. In this setting, participants also described having to audit the medical record to extract the data,
a process that is time consuming. In most instances, individuals did describe the feedback of this information back to the clinician decision makers.

The interviewer often had to probe in the areas of outcomes, implementation and training, and organizational readiness. All of these were constructs that resonated with clinicians and that they were able to discuss fully after they had been brought up. Outcomes were described as important, although not always immediately visible at the bedside. People who felt strongly about an intervention often talked about outcomes and effectiveness as the opportunity to make real positive impact in the clinical setting. When describing implementation and training, clinicians acknowledge the difficulty with ongoing training. Sometimes this was due to turnover but often it was simply because individuals needed reminders or because practice drift had occurred. Finally, people mentioned the need for resources and staff time and effort within the idea of organizational readiness. Participants mentioned barriers to organizational readiness, such as competing interests or other burdens on the team. Due to the timing of these interviews, COVID-19 was also mentioned as relevant to the organization with considering implementation and sustainability.

Program differences

Overall, the way that individuals discussed the sustainability of the programs did not vary based on the program. Participants talked about the actors, systems, and daily cadence of work in similar ways. The largest difference in the programs was how people talked about the interventions and the acuity of care at the time of delivery. Antimicrobial prescribing occurs multiple times per day in mostly calm and planned settings. While early mobility occurs in the setting of acute care, they happen when a patient is stable and ready for rehabilitation. Transfusion protocols, however, happen in the setting of life-threatening bleeding and during times when a patient is at their most unstable. There are also a high number of patient deaths
that occur in this setting, which means that there are high stakes. This was conveyed as practitioners discussed decision making around these protocols. The programs also had different levels of integration across the hospital system. Early mobility is mostly within one team, antimicrobial stewardship incorporates patients across the entire hospital, and transfusion programs bring together multiple specialties at one time, most often in the emergency department or intensive care unit. However, these programs still described similar interpersonal dynamics amongst their stakeholders.

**Mindsets of professionals**

All of the participants that were interviewed conveyed a commitment to their career and a passion for taking good care of children. While this was not a specific question in the interview guide, and was not always directly addressed by the clinician in this manner, it was a thread throughout the conversations. Sometimes this was illuminated in how clinicians described their necessary duties or in their motivation behind continuing to deliver a specific intervention. Clinicians desire to find solutions for sustainability because of this desire to reach full impact for their patients. This is well summarized through one of the team members, when they stated: “what I do think about is, I think about patients. What's good for the patients? Because I'm here for the patient’s sake.”

**Discussion**

To ultimately ensure the sustainability of evidence-based practices, it is critical to understand what is most relevant for frontline staff. While the prevalence of research answering questions about sustainability definitions, measures, and interventions is increasing, there remains a lack of research that interfaces directly with frontline clinical staff engaged in evidence-based care delivery. This study used the EPIS
framework and CSAT to identify how frontline clinicians conceptualize and discuss sustainability capacity within pediatric healthcare settings. These results help understand what constructs are relevant for improvements in sustaining evidence-based care delivery.

**Perceptions and Beliefs about Clinical Sustainability (Research Question 1)**

The concept of sustainability of interventions was something that resonated with clinical staff. While individuals described sustainability differently concerning duration, penetration, and adaptation, it was something that people believed was necessary to deliver high-quality care. Those who had participated in program implementation understood that this concept was not always easy to realize in practice and that there is a large time and resource burden to think about how to increase sustainability. A previous study interviewed leaders and staff to define sustainability and found that individuals believed that innovations must continue in the absence of the original implementation team [101]. This study found that clinicians considered sustainability to be the similar continued delivery, but they believed this extraction outside of the original implementation team was difficult, if not impossible, the way clinical environments are currently structured.

Also similar to other literature was a finding that finances were not perceived as necessary to the continuation of a program [102]. While resources and staffing are important to good clinical programming, individuals at the frontlines of care did not think about these things in relationship to the budget or financial stability of their practice. Some clinicians discussed obtaining support through demonstrating a financial benefit, but it was not directly concerning the continued cost of the program. This signifies potential differences in consideration of money by hospital hierarchy and signals an important difference between public health and clinical sustainability. This has been similarly found in
framework development, with public health programming having more focus on financial security than clinical capacity [36, 37].

Relevant Constructs for Sustainability (Research Question 2)

For the individuals delivering clinical interventions at the bedside, there was mention of many factors of clinical sustainability that align with the Clinical Sustainability Assessment Tool framework [36]. All of the CSAT domains were discussed during the interviews. Each construct that did not emerge organically was inquired about during the interview and clinicians acknowledged that the concept resonated with them, even if it was something they had not initially mentioned. This highlights that there might be different constructs that have been emphasized in a clinical setting or are more relevant to those on the delivery team. Future work could focus on these potential differences and understanding how this should be accounted for in future measurement development or intervention design. This would suggest that certain interventions should be targeted at different parts of the system, such as spending more time assisting with stakeholder engagement and monitoring as opposed to implementation and training.

When considering what factors are important for sustainability, participants spent the most time discussing social influences within the team and how to get support for the intervention. This included engagement at multiple levels of the institution but focused most on the immediate team members as opposed to higher-level leadership such as management or administration. This aligns with other literature suggesting that relationships can influence behaviors and suggests that who is involved in the intervention could be more important than the evidence or processes that are developed.

When moving into the outer context description of determinants, the EPIS framework provides important and useful language and concepts. In the EPIS framework, there is a construct called bridging factors that
explains the relationship or interplay between the outer and inner context where intervention might be implemented [53]. While clinicians did not use this terminology, they did describe the ways that the unit and organization influence each other, often in unintended ways. The EPIS framework in the medical setting might look more like an inner setting of a team or medical unit and an outer context of the organization or hospital system, as opposed to the way it has been described in community organizations. This, though, means that the policies, medical record system, and other structural elements to the organization do function as bridging factors, either facilitating or hindering the ongoing sustainment of evidence-based practice.

The way that clinicians described some of these differences was also apparent when discussing organizational readiness. Within the CSAT framework, organizational readiness is thought of as the readiness within the setting wherein the practice is occurring. However, this is not always at the ‘organizational’ level, as clearly articulated when clinicians were discussing the team and unit versus the larger organization. For this domain, the concept might be better conceptualized as something like care team readiness. The definition would remain the same, but the unit would no longer focus on the larger outer context, but instead the inner setting.

Clinical Roles Contributing to Sustainment (Research Question 3)

In addition to an assessment of the constructs of clinical sustainability, participants reflected on their role in maintaining evidence-based practices. People largely described participating in one of two roles: (1) through remembering to deliver the intervention when appropriate or (2) through audit and feedback regarding the practice. Both roles were described mainly focusing on a large amount of time and effort required by the individual. Additionally, this focus on the individual as the ‘sustainer’ requires an
expectation that the individual simply remembers that the tasks need to be completed as opposed to having embedded triggers or reminders.

Overall, regardless of the role, clinicians described sustainability in terms of workload. While it might be true that the burden can never disappear, the nature of the conversation was interesting in that it was not always presented as something that goes away or folds into other tasks. When describing interventions, clinicians always described taking on more and more, but never reducing or streamlining. Further, for those who audit the intervention, it was never described in terms of ultimate integration into the workflow. One participant even described the threat of an intervention ending if the champion responsible for auditing the intervention left the institution. Understanding ways to reduce this burden on clinicians and develop ways to leverage information systems will ultimately help increase sustainability capacity for constant learning and integration of new practices within a team.

**Conclusion**

This analysis contributes a frontline provider perspective on sustainability capacity and provides initial consideration for the areas of feasible intervention in clinical settings to increase sustainability. Understanding more about the provider experience informs future practice and research development in this field. Additionally, this provides reassurance that the CSAT framework measures address areas of sustainability capacity that are relevant to clinicians. These results add to the increasing evidence for the validity of the CSAT. This includes confirmation that sustainability of a clinical practice is seen by frontline providers as important and relevant for their jobs. It also reinforces that sustainability capacity of a clinical practice is something that clinicians have a role in shaping and improving.
Chapter 4: Communication Structures and Sustainability in Pediatric Antimicrobial Stewardship Teams
Background

Antimicrobial Stewardship Programs & Sustainability Research

Over the past 15 years, antimicrobial stewardship programs have emerged within hospitals to promote responsible antimicrobial use and improve guideline-adherent prescribing practices [117]. The programs are often comprised of, at minimum, a pharmacist and physician team that are available to help with monitoring of prescribing practices, educating clinicians regarding appropriate prescribing, and developing guidelines that impact both the inpatient and outpatient clinical settings [118]. These programs have demonstrated continued success in reducing inappropriate prescribing, lowering hospital costs, and improving the quality of healthcare delivery across many different healthcare settings [117-119].

Stewardship teams have been the focus of implementation research [120-122], including specific studies on audit and feedback [123, 124]. However, until now these kinds of programs have not been used to study sustainability. For this dissertation study, we take advantage of an existing ASP partnership to examine how communication structures in clinical settings may be related to sustainability capacities within those settings.

Surgeons and Stewardship

Part of the unique nature of stewardship programs has been in their conceptualization as boundary spanners, interfacing with numerous different subspecialties. While many of these medical subspecialties have been characterized and stereotyped, surgeons are especially known for their emphasis on individual decision-making and have sometimes been characterized as difficult to work with [125, 126]. It has been suggested that there is a unique relationship between surgeons and stewards and that this should be studied.
with full appreciation of how surgical stewardship might be unique [125]. Studies have demonstrated the benefits of team based care in terms of team processes, cost, and patient outcomes [127]. There is still a gap in the literature assessing the roles of surgeons in team-based care. Most of the literature has focused on the need to bolster the evidence based to inform appropriate intervention or has focused solely on the surgical role, and not the relationship amongst surgery and stewardship teams [128-130].

Engagement and Sustainability

Stakeholder engagement and the relationship between different staff are key domains within the Clinical Sustainability Assessment Tool framework, aimed at understanding how sustainability capacity exists in clinical healthcare organizations and settings [36]. Sustainability capacity is a term used to describe the clinical context that enables a setting to continue to deliver practices over time. Many different ways of measuring context are needed to understand this capacity, which could be described as the accumulation of many different organizational level determinants.

While theories related to effective sustainment have become more prevalent in the literature, there remains a gap in knowledge of the relationship between proposed determinants of sustainability and actual sustainment in clinical settings [7, 17]. Specifically, we currently do not fully understand how the people and other social structures that make up these complex organizations influence the sustainability of evidence-based practices. Networks of individuals have already been identified as important to the dissemination and implementation of evidence-based practices [131]. Physicians’ interaction with their professional community, including other physicians, also influences decision-making and prescribing practices [132]. It is important to understand if links between individuals within healthcare settings are significant for the sustainment of practices in clinical settings.
Networks and Knowledge Translation

Social networks have been described as informal and unplanned communication patterns within social systems [133]. Network studies in healthcare have focused both on interorganizational connections as well as relationships among people (i.e., healthcare staff) within those organizations [134-136]. Organizational level network analysis studies as questions about how different institutions might be connected throughout a healthcare system [137]. However, networks can be used to learn about the diffusion of information, understand communication structures, and identify certain key actors within the system. In healthcare, network analysis has been used previously to assess the social ties between providers [138]. It remains unknown what types of individual actors and patterns of communication structure produce the greatest capacity of sustainability. For instance, recent work has highlighted that simply having champions is important but not sufficient to foster implementation outcomes [139]. Social network analysis, a systems science method, assists in understanding complexity and complex systems [140]. It is a fundamental way of measuring these communication patterns that exist in various settings. However, social network analysis in knowledge translation literature has been mostly been used in individual decision-making evaluation as opposed to examining meso-level interactions like those between the antimicrobial stewardship teams and surgical subspecialties [141].

Communication Networks as Structural Determinants of Sustainability

Communication networks influence how a healthcare team functions within an organization. For example, an organization with stronger interpersonal communication networks has increased knowledge and spread of information throughout the network [142]. This, in turn, has been shown to change individual behavior and decision making [143]. Studies such as these provide insight that the network structures within a system can link to organizational characteristics and behaviors. While other studies have assessed
networks and information seeking around evidence-based practice [144], there lacks research linking these networks within a healthcare setting to contextual determinants relevant for implementation science. This study focuses on the link between communication structures and sustainability capacity, theorizing that organizations with stronger communication structures would have a higher sustainability capacity.

**Objective & Research Questions**

Bringing all of this together, the relationship between surgeons and antimicrobial stewards is important to understand for multiple reasons. This will not only add to an understanding of how stewardship programs function in hospitals, but it will enhance our understanding of how these networks ultimately influence the sustainability of practices in clinical settings. Conducting this analysis through network theory and methods allows for measurement of context that is open to understanding different, more nuanced factors that could help shape an understanding of context. This study is designed to understand the underlying communication structures within healthcare systems and how these may contribute to the sustainment of evidence-based practices.

The current study will assess the communication structures of clinical antimicrobial stewardship teams and their relationship with clinical sustainability across nine hospitals. It will answer the following two research questions:

1. What are the patterns of communication among stewardship teams?
   a. What are the types of general and collaboration-specific communication that occur regarding antimicrobial stewardship in surgical settings?
   b. What are the roles of social networks in knowledge acquisition among different subspecialties?
(2) How do communication networks of stewardship teams relate to sustainability capacity?

When this study is completed, it will improve understanding of how to utilize network analysis to understand structural factors that relate to the sustainability of interventions in hospital settings. This will be a useful contribution to sustainability theory, resulting in information regarding a causal link between organizational context and the sustainment of evidence-based practices. Methodologically, this helps join together healthcare practice and implementation science in a practical, applied understanding of ways that network science can better contribute to a systemic understanding of healthcare improvement. In addition, this study will help further validate the concept of clinical sustainability by demonstrating how communication structures in healthcare settings are implicated in the sustainability capacity of those settings.

**Methods**

This study is an observational network study of communication patterns and perceived sustainability capacity within healthcare teams at nine hospitals. Data were collected through two surveys. The network survey was analyzed using social network analysis and then assessed with the total sustainability capacity score. This study was reviewed and approved by Washington University in St. Louis Investigational Review Board.

*Parent Study*

This dissertation study takes advantage of an existing parent study (PI, Newland) of a trial working to increase guideline adherent prescribing practices in surgical cases (Operatic) [80]. The Operatic trial uses
a cluster-randomized stepped-wedge design to test the role of facilitation in amplifying the work of antimicrobial stewardship teams implementing evidence-based guidelines in clinical surgery. At the time of data collection, all sites were in the baseline phase. Nine academic children’s hospitals across the US are enrolled, all with active antimicrobial stewardship programs (ASP). Operatic utilizes the i-PARIHS framework and assesses two change strategies: order set review and order set review plus facilitation.

Participants

The participants were recruited from nine academic medical centers. All of these are freestanding children’s hospitals with surgical programs and antimicrobial stewardship programs already implemented. Each of the hospitals is in the United States and is a member of the Sharing Antimicrobial Reports for Pediatric Stewardship (SHARPS) collaborative [145].

The entirety of the antimicrobial stewardship team and a few surgeon champions at each of the nine hospitals were asked to describe their antibiotic prophylaxis prescribing practices and assess their associated sustainability capacity. All members of the antimicrobial stewardship teams and the surgical teams at each of the nine hospitals were recruited to complete the network survey. Any prescribing practitioner (physician, nurse practitioner, physician assistant) involved with the surgical subspecialties was included in the surgical sample.
Instruments

Social network survey

A social network survey (Appendix E) was developed by the research team for completion amongst all participants. A roster was generated for each site and individuals were asked to select all other individuals with whom they had any contact in the past year. After completing that initial task, they were then asked to indicate types of communication, and information seeking with the people who they had been in contact.

Table 12 outlines each of the variables, their meaning, and the type of tie in the network. Individuals were asked to identify anyone on the roster with whom they had contact in the past year about antibiotic prescribing in surgery, creating the overall contact network. A smaller roster was created from this question, and individuals identified the type of communication they had with another individual. Participants could select all that applied, which created the different types of communication networks: clinical, committee, standardized care, quality improvement, and research. An additional aggregate network of any specific communication type was created. Finally, individuals identified others in the network that they would seek out if they were looking for expertise in the area of surgical antibiotic prescribing.
<table>
<thead>
<tr>
<th>Tie Name</th>
<th>Meaning</th>
<th>Tie Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Contact</td>
<td>Individuals have had any sort of contact regarding surgical antibiotic prescribing within the last year</td>
<td>Non-directed</td>
</tr>
<tr>
<td>Clinical Communication</td>
<td>Communication between two individuals within the past year is regarding clinical care, or around prescribing for patient care</td>
<td>Non-directed</td>
</tr>
<tr>
<td>Committee Communication</td>
<td>Communication between two individuals within the past year is regarding a committee that discusses surgical prescribing</td>
<td>Non-directed</td>
</tr>
<tr>
<td>Standardized Care</td>
<td>Communication between two individuals within the past year is regarding standardizing care, often through guidelines</td>
<td>Non-directed</td>
</tr>
<tr>
<td>Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality Improvement</td>
<td>Communication between two individuals within the past year is regarding quality improvement initiatives or projects about surgical antibiotic prescribing</td>
<td>Non-directed</td>
</tr>
<tr>
<td>Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Communication</td>
<td>Communication between two individuals within the past year is regarding a research study about surgical antibiotic prescribing</td>
<td>Non-directed</td>
</tr>
<tr>
<td>Any Communication</td>
<td>This is a cumulative of communication in the setting of: research, quality improvement, standardized care, committee work, or clinical care</td>
<td>Non-directed</td>
</tr>
<tr>
<td>Information Seeking</td>
<td>This tie is the identification of individuals that someone would ask or seek out if they had questions about surgical antibiotic prescribing</td>
<td>Directed</td>
</tr>
</tbody>
</table>

Table 12. Overview of variables in network survey.

Clinical sustainability assessment tool

The Clinical Sustainability Assessment Tool is a 35-question tool with seven domains: engaged stakeholders, engaged staff and leadership, organizational readiness, monitoring and evaluation, implementation and training, outcomes and effectiveness, and workflow integration [36]. This tool demonstrated strong reliability and usability in development and pilot testing. Additionally, there was good preliminary validity, suggesting that the tool measures clinical sustainability as intended. All
questions are completed on a seven-point Likert scale with options ranging from: not at all – to a great extent. There is also a “not applicable” option for each question.

Design

This study was an observational, descriptive network study. Survey methods were used to collect data on communication, information seeking, and sustainability capacity. Individuals were invited to complete surveys over email by the study team along with two champions at each site. Individuals received three follow-up emails and after that, the survey was closed. Individuals did not receive compensation for participating in the study.

Data Analysis

Once the data set was created, the igraph package in R [146] was used to analyze and depict the networks. Below, the names of the sites were removed for confidentiality. For research question #1, overall communication networks were created as well as networks for each type of communication and for information seeking. For the information-seeking network, directed ties were depicted with arrows to show directionality. After these basic network visualizations were created, the data were assessed with a focus on the antimicrobial stewardship teams. Network metrics, including density, diameter, and E-I index, were calculated for the overall contact for each site and as well as for each type of communication network. Density reflects the interconnectedness of a social network, ranging from 0 (completely unconnected) to 1 (completely connected). Diameter indicates how far apart nodes are in a network, a large diameter indicates it takes many steps for information to get from one part of a network to other parts [61]. The E-I index is a ratio of external connections to internal connections with reference to a
classification of network nodes [147]. Here it is used to explore the external vs. internal tie patterns of the antimicrobial steward teams within the hospital sites.

For research question #2, network characteristics of the nine participating hospital programs were related to CSAT scores using a variety of relational tools, including correlations, bivariate regressions, and scatterplots. These analyses are descriptive, rather than inferential. Given the small number of hospitals in this study, we cannot examine significance of these relationships.

Centralization is a network measure that helps assess how hierarchical the structure is [148]. Specifically, betweenness centralization is a measure of how often nodes are present along the shortest path across the network [149, 150]. This assesses the extent to which specific individuals control the flow of information across a network [150]. High betweenness centralization indicates a few members of a network control the flow of information across a social system, while low centralization indicates a flatter communication structure where no individual or small groups of members control the flow of information. In addition to network density, we used betweenness centralization [151] to assess the overall structural pattern of communications within the hospital settings.

**Results**

A total of 342 participants from nine hospitals completed the network survey. Following standard organizational network practices, those who did not respond to the survey were still included in the final network. The networks for each hospital consisted of surgical specialties as well as the antimicrobial stewards at each site. Individual characteristics of the study participants are presented in Table 13. Three sections of results are presented below. First, we review the overall contact and communication networks, which are non-directed networks. Second, we present the directed networks derived from the information-
seeking questions and assess similarities and differences amongst subspecialties at each of the nine sites.

Finally, we review the networks in relationship to clinical sustainability capacity scores of each of the nine sites.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
<th>Site 5</th>
<th>Site 6</th>
<th>Site 7</th>
<th>Site 8</th>
<th>Site 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacist</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Physician</td>
<td>64</td>
<td>92</td>
<td>50</td>
<td>56</td>
<td>98</td>
<td>50</td>
<td>49</td>
<td>93</td>
<td>72</td>
</tr>
<tr>
<td>NP</td>
<td>47</td>
<td>14</td>
<td>7</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>30</td>
<td>0</td>
<td>43</td>
</tr>
<tr>
<td>PA</td>
<td>5</td>
<td>51</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>14</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>PhD</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Antimicrobial Stewards</td>
<td>11</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Surgeons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>8</td>
<td>12</td>
<td>7</td>
<td>7</td>
<td>10</td>
<td>11</td>
<td>10</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>General Surgery</td>
<td>24</td>
<td>32</td>
<td>24</td>
<td>16</td>
<td>9</td>
<td>6</td>
<td>17</td>
<td>19</td>
<td>31</td>
</tr>
<tr>
<td>Plastic Surgery</td>
<td>9</td>
<td>18</td>
<td>8</td>
<td>8</td>
<td>14</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Urology</td>
<td>9</td>
<td>16</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>3</td>
<td>12</td>
<td>11</td>
<td>12</td>
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<td>Orthopedic Surgery</td>
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<td>39</td>
<td>5</td>
<td>12</td>
<td>21</td>
<td>24</td>
<td>28</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>Otolaryngology</td>
<td>22</td>
<td>39</td>
<td>12</td>
<td>21</td>
<td>33</td>
<td>7</td>
<td>17</td>
<td>18</td>
<td>20</td>
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<tr>
<td>Total Surgeons</td>
<td>109</td>
<td>156</td>
<td>66</td>
<td>75</td>
<td>99</td>
<td>59</td>
<td>95</td>
<td>91</td>
<td>119</td>
</tr>
<tr>
<td>Total Respondents</td>
<td>120</td>
<td>160</td>
<td>70</td>
<td>78</td>
<td>102</td>
<td>62</td>
<td>100</td>
<td>94</td>
<td>122</td>
</tr>
</tbody>
</table>

Table 13. Demographics of network participants.
Research Question 1 – What are the patterns of communication across the stewardship teams?

What do the networks look like?

Table 14 presents the non-directed overall contact network data for each of the nine sites. Overall, the nine networks all have a low to moderate density. Site 6 has the highest density at 0.29 with Site 5 having the lowest density (0.09). Further, the Site 5 network has numerous isolates, indicating individuals completely disconnected from their colleagues. All of the other networks have one component, highlighting that all individuals are connected to at least one other person within the larger network, ultimately resulting in all individuals being connected at some level. The diameters for the network range from 3-5. This gives an idea that even though these networks are not considered dense, they could pretty easily get information across the network, especially given the size of the networks. The average degree, which is the average number of ties from each individual, ranges from just under 9 to just under 25. Finally, this table presents the E-I index for the antimicrobial stewardship teams. This index measures the connections between the stewardship teams when compared to the connections between stewardship teams and their surgical colleagues. The E-I index illustrates a high degree of collaboration outside of the ASP group, with a maximum possible external score of +1.

<table>
<thead>
<tr>
<th></th>
<th>Density</th>
<th>Average Degree</th>
<th>Diameter</th>
<th>Components</th>
<th>ASP E-I Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>0.21</td>
<td>24.9</td>
<td>4</td>
<td>1</td>
<td>0.73</td>
</tr>
<tr>
<td>Site 2</td>
<td>0.12</td>
<td>19.1</td>
<td>4</td>
<td>1</td>
<td>0.77</td>
</tr>
<tr>
<td>Site 3</td>
<td>0.23</td>
<td>14.9</td>
<td>4</td>
<td>1</td>
<td>0.83</td>
</tr>
<tr>
<td>Site 4</td>
<td>0.19</td>
<td>14.2</td>
<td>4</td>
<td>1</td>
<td>0.93</td>
</tr>
<tr>
<td>Site 5</td>
<td>0.09</td>
<td>8.9</td>
<td>5</td>
<td>12</td>
<td>0.92</td>
</tr>
<tr>
<td>Site 6</td>
<td>0.29</td>
<td>16.4</td>
<td>3</td>
<td>1</td>
<td>0.95</td>
</tr>
<tr>
<td>Site 7</td>
<td>0.16</td>
<td>15.2</td>
<td>3</td>
<td>1</td>
<td>0.91</td>
</tr>
<tr>
<td>Site 8</td>
<td>0.14</td>
<td>13.7</td>
<td>4</td>
<td>1</td>
<td>0.88</td>
</tr>
<tr>
<td>Site 9</td>
<td>0.10</td>
<td>11.93</td>
<td>5</td>
<td>5</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Table 14. Contact descriptive information for the nine networks.
Figures 12, 13, and 14 present the *contact* network visualizations for each of the sites, grouped by high, medium, and low density. The highest density sites, while all interconnected, have different centrality of antimicrobial stewards within the network. The network visualization for sites 5 and 9 (Figure 14) also contains numerous isolates, illustrating there are individuals who were not connected to anyone else within the network. In five of the networks, there is at least one antimicrobial stewardship team member (denoted by red squares) that is fairly centrally located in the network. This centrality is due to the degree of connectedness of these individuals. In contrast, the site 2 network does not have any members of the antimicrobial stewardship team central to the visualization. Instead, this network visualizes general and plastic surgery team members as the most prominent in the network.
Figure 12. Overall contact network for three highest degree sites
Figure 13. Overall contact networks for three middle degree sites.
What are the types of general and collaboration-specific communication that occur regarding antimicrobial stewardship in surgical settings?

After asking about general contact, each individual was asked about the type of communications they had with other network members with regards to antimicrobial prescribing in surgery. This was analyzed by...
each of the five options and as a cumulative category summarizing any type of communication. The options for types of communication were: clinical (patient) care, committee service, care standardization (e.g., guideline development), research work, and quality improvement initiatives. Table 15 presents the density and E-I index for each site by the type of communication.

Overall, there is low density across all types of communication. This suggests that even if people have had communication about surgical antibiotic prescribing, it has rarely been in the context of any of these common collaboration settings. Of the communication opportunities, most of the ties exist in the setting of clinical patient care, which is the setting in which two or more professionals are making a decision about prescriptions for a specific patient. The low densities (ranging from 0.01-0.07) indicate that there has been very little work in the areas of research, quality improvement, or committee work. The E-I indices for all sites aside from site 1 emphasize that individuals are slightly more likely to work outside their specialties as opposed to collaborating simply within a single team. The site 1 E-I indices for committee (-0.10), standardized care (-0.07), research (-0.67), and QI work (-0.15) suggest a tendency towards working internally as subspecialties instead of across the network. This is in contrast to the clinical E-I index (0.82). This difference notes that the teams do communicate externally when making patient care decisions. However, these types of communication patterns are less common in other contexts where systematic care improvement decisions are made (e.g., quality improvement, guideline, committee work).

Figure 15 shows network diagrams for different communication types for site 1 as an example of how these differences are seen within the visualizations. Appendix F contains all of the network visualizations for each site.
<table>
<thead>
<tr>
<th>Types of Communication</th>
<th>Clinical Density</th>
<th>Clinical E-I Index</th>
<th>Committee Density</th>
<th>Committee E-I Index</th>
<th>Standardized Care Density</th>
<th>Standardized Care E-I Index</th>
<th>Research Density</th>
<th>Research E-I Index</th>
<th>QI Density</th>
<th>QI E-I Index</th>
<th>Any Communication Density</th>
<th>Any Communication E-I Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>0.16</td>
<td>0.82</td>
<td>0.02 -0.10</td>
<td>0.04 -0.07</td>
<td>-0.07</td>
<td>0.02</td>
<td>-0.67</td>
<td>0.03</td>
<td>-0.15</td>
<td>0.18</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>Site 1</td>
<td>0.06</td>
<td>0.76</td>
<td>0.01 0.23</td>
<td>0.02 0.41</td>
<td>0.01 0.50</td>
<td>0.02</td>
<td>0.33</td>
<td>0.02</td>
<td>0.33</td>
<td>0.07</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td>0.16</td>
<td>0.74</td>
<td>0.03 0.40</td>
<td>0.06 0.76</td>
<td>0.02 0.33</td>
<td>0.04</td>
<td>0.57</td>
<td>0.18</td>
<td>0.18</td>
<td>0.82</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>Site 4</td>
<td>0.11</td>
<td>0.92</td>
<td>0.01 0.68</td>
<td>0.03 0.83</td>
<td>0.02 0.46</td>
<td>0.02</td>
<td>0.76</td>
<td>0.12</td>
<td>0.76</td>
<td>0.12</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td>Site 5</td>
<td>0.05</td>
<td>0.91</td>
<td>0.01 0.71</td>
<td>0.01 0.71</td>
<td>0.01 0.68</td>
<td>0.02</td>
<td>0.87</td>
<td>0.05</td>
<td>0.87</td>
<td>0.05</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Site 6</td>
<td>0.22</td>
<td>0.94</td>
<td>0.04 0.78</td>
<td>0.07 0.91</td>
<td>0.03 0.60</td>
<td>0.04</td>
<td>0.84</td>
<td>0.23</td>
<td>0.84</td>
<td>0.23</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>Site 7</td>
<td>0.10</td>
<td>0.67</td>
<td>0.02 0.00</td>
<td>0.03 0.55</td>
<td>0.01 0.14</td>
<td>0.03</td>
<td>0.28</td>
<td>0.11</td>
<td>0.28</td>
<td>0.11</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>Site 8</td>
<td>0.08</td>
<td>0.79</td>
<td>0.01 0.33</td>
<td>0.01 0.71</td>
<td>0.01 0.14</td>
<td>0.01</td>
<td>0.76</td>
<td>0.09</td>
<td>0.76</td>
<td>0.09</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Site 9</td>
<td>0.07</td>
<td>0.94</td>
<td>0.01 0.33</td>
<td>0.02 0.54</td>
<td>0.01 0.14</td>
<td>0.02</td>
<td>0.65</td>
<td>0.07</td>
<td>0.65</td>
<td>0.07</td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.112</td>
<td>0.819</td>
<td>0.0178 0.3733</td>
<td>0.032 0.594</td>
<td>0.0156 0.2725</td>
<td>0.025</td>
<td>0.5456</td>
<td>0.122</td>
<td>0.5456</td>
<td>0.122</td>
<td>0.852</td>
<td></td>
</tr>
</tbody>
</table>

Table 15. Network descriptive information by type of communication.
What are the roles of social networks in knowledge acquisition among different subspecialties?

Directed networks were developed utilizing the question about information seeking. In the question, individuals identified other colleagues that they would approach with a question about perioperative antibiotic prescribing. Nine network figures were developed, one for each of the sites, and network statistics were calculated at the site level. Figure 16 shows three of the networks that were developed (full...
network figures can be found in Appendix G). Table 16 presents the network characteristics for information seeking for each of the sites. The density of these networks ranged from 0.09 to 0.35. There are twice as many possible connections in the directed network due to the possibility of bi-directional information seeking.

Sites 1 and 6 had the two highest densities and also had high average indegree statistics. The lowest density networks were site 9 (0.10) and site 5 (0.09). However, the ASP E-I, a statistic highlighting the amount of external networking, was high for all sites. The EI ranged from 0.73 (Site 1) to 0.94 (Site 4), suggesting a high amount of external collaboration across all nine ASP teams. Sites 5 and 9 had networks that had more than one component, but the other seven sites all had one connected network diagram. Overall, the diameter of all of the networks was still small, suggesting that these were also compact networks. These networks illustrate that individuals identified more than one person that they sought information from on the topic.

<table>
<thead>
<tr>
<th>Site</th>
<th>Density</th>
<th>Average Degree</th>
<th>Avg. Indegree</th>
<th>Diameter</th>
<th>Components</th>
<th>ASP EI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>0.33</td>
<td>78.65</td>
<td>39.33</td>
<td>3</td>
<td>1</td>
<td>0.73</td>
</tr>
<tr>
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<td>0.35</td>
<td>40.98</td>
<td>20.49</td>
<td>3</td>
<td>1</td>
<td>0.92</td>
</tr>
<tr>
<td>Site 7</td>
<td>0.15</td>
<td>28.06</td>
<td>14.03</td>
<td>3</td>
<td>1</td>
<td>0.80</td>
</tr>
<tr>
<td>Site 8</td>
<td>0.19</td>
<td>34.62</td>
<td>17.31</td>
<td>2</td>
<td>1</td>
<td>0.91</td>
</tr>
<tr>
<td>Site 9</td>
<td>0.10</td>
<td>22.71</td>
<td>11.36</td>
<td>4</td>
<td>3</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Table 16. Network characteristics for information seeking.
Prestige (as measured by in-degree) was assessed to understand the relative importance of the ASP team members when compared to surgical team members in the network. This is useful in the directed network to understand how often the ASP team members are the person from whom information is sought compared to the surgeons. This is measured as the average in-degree for the members of these respective affiliations. Table 17 presents the indegree centrality for information seeking for the ASP team, surgical specialties (Other), and overall. In eight of the sites, other team members had higher prestige than the ASP team. The one site where the ASP team had a higher prestige score had very low scores overall. This suggests that for most of these sites, it is slightly more common for individuals to seek information from other surgeons as opposed to the antimicrobial stewardship teams. The differences are quite small.

Overall, individuals seek out multiple types of clinicians when gathering information related to this topic. In the networks visualized in Figure 16, the antimicrobial stewards (identified as red squares) are targets of information seeking.

<table>
<thead>
<tr>
<th></th>
<th>ASP Team</th>
<th>Others</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>0.25</td>
<td>0.34</td>
<td>0.29</td>
</tr>
<tr>
<td>Site 1</td>
<td>0.07</td>
<td>0.13</td>
<td>0.10</td>
</tr>
<tr>
<td>Site 3</td>
<td>0.136</td>
<td>0.257</td>
<td>0.197</td>
</tr>
<tr>
<td>Site 4</td>
<td>0.173</td>
<td>0.256</td>
<td>0.215</td>
</tr>
<tr>
<td>Site 5</td>
<td>0.091</td>
<td>0.085</td>
<td>0.088</td>
</tr>
<tr>
<td>Site 6</td>
<td>0.299</td>
<td>0.350</td>
<td>0.325</td>
</tr>
<tr>
<td>Site 7</td>
<td>0.114</td>
<td>0.150</td>
<td>0.132</td>
</tr>
<tr>
<td>Site 8</td>
<td>0.106</td>
<td>0.187</td>
<td>0.147</td>
</tr>
<tr>
<td>Site 9</td>
<td>0.090</td>
<td>0.096</td>
<td>0.093</td>
</tr>
</tbody>
</table>

Table 17. Indegree centrality for information seeking.
Figure 16. Information seeking networks for three sites.

Research Question 2 - How do communication networks of stewardship teams relate to sustainability capacity?

What are the sustainability capacities of the sites?
Table 18 presents the scores for each domain as well as the overall sustainability capacity for each of the nine sites. All nine sites have overall CSAT scores that range from 4.55 to 5.49. The site 6 and 8 hospitals have the highest CSAT scores overall. All sites have high scores in the domains of engaged staff and engaged stakeholders, which are the domains that capture the people who are engaged in the organization. The sites had lower scores in Implementation and training and Monitoring and Evaluation. While there is some restriction of range within each domain as well as in the overall CSAT score, there is some variation in the scores. For the network analysis, the Engaged Staff and Leadership and Engaged Stakeholder domains as well as the overall CSAT score are of particular interest.

<table>
<thead>
<tr>
<th>Site</th>
<th>CSAT Total</th>
<th>Engaged Staff</th>
<th>Engaged Stakeholder</th>
<th>Organizational Readiness</th>
<th>Workflow Integration</th>
<th>Implementation and Training</th>
<th>Monitoring and Evaluation</th>
<th>Outcomes and Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>5.05</td>
<td>5.25</td>
<td>4.51</td>
<td>5.31</td>
<td>5.13</td>
<td>4.54</td>
<td>5.17</td>
<td>5.44</td>
</tr>
<tr>
<td>Site 2</td>
<td>4.58</td>
<td>5.00</td>
<td>4.96</td>
<td>4.56</td>
<td>4.40</td>
<td>4.41</td>
<td>4.12</td>
<td>5.73</td>
</tr>
<tr>
<td>Site 3</td>
<td>4.77</td>
<td>5.33</td>
<td>4.36</td>
<td>5.36</td>
<td>5.24</td>
<td>4.56</td>
<td>4.68</td>
<td>4.50</td>
</tr>
<tr>
<td>Site 4</td>
<td>4.55</td>
<td>4.87</td>
<td>4.23</td>
<td>4.44</td>
<td>4.36</td>
<td>4.30</td>
<td>4.15</td>
<td>6.15</td>
</tr>
<tr>
<td>Site 5</td>
<td>5.21</td>
<td>5.53</td>
<td>5.72</td>
<td>5.13</td>
<td>5.00</td>
<td>5.27</td>
<td>4.73</td>
<td>5.87</td>
</tr>
<tr>
<td>Site 6</td>
<td>5.49</td>
<td>5.70</td>
<td>4.80</td>
<td>5.70</td>
<td>6.05</td>
<td>5.45</td>
<td>4.85</td>
<td>5.90</td>
</tr>
<tr>
<td>Site 7</td>
<td>4.68</td>
<td>5.00</td>
<td>4.52</td>
<td>5.44</td>
<td>5.28</td>
<td>3.84</td>
<td>3.80</td>
<td>4.89</td>
</tr>
<tr>
<td>Site 8</td>
<td>5.40</td>
<td>5.83</td>
<td>5.12</td>
<td>5.07</td>
<td>4.93</td>
<td>5.16</td>
<td>5.60</td>
<td>6.07</td>
</tr>
<tr>
<td>Site 9</td>
<td>4.67</td>
<td>4.67</td>
<td>4.01</td>
<td>5.80</td>
<td>5.20</td>
<td>3.60</td>
<td>3.73</td>
<td>5.13</td>
</tr>
</tbody>
</table>

Table 18. Overall CSAT scores and domain averages for each site.

Relationship of network interconnectedness (i.e., density) to sustainability capacity

Overall, there is a small to moderate positive relationship between the calculated densities of the networks and the CSAT score. The associations were plotted for the overall CSAT score predicted by four densities: overall contact (Figure 17), clinical communication (Figure 18), any communication (Figure 19), and
information seeking (Figure 20). Across the sites, there are consistent findings that suggest a positive relationship. This means that hospital teams that have greater connectedness tend to report greater sustainability capacity. Additionally, higher amounts of information seeking behaviors also increase sustainability score. This positive relationship holds across the three types of network ties (contact, communication, and information seeking). Due to small sample size, these results are not significant. Overall, these figures illustrate that settings with larger interconnectedness may have higher sustainability capacities.

Figure 17. Association of total CSAT score to contact density network for each site.
Figure 18. Association of total CSAT score to clinical communication density network for each site.
Figure 19. Association of total CSAT score to any communication network density for each site.
Figure 20. Association of total CSAT score to information seeking network density for each site.

Relationship of network communication hierarchy (i.e., betweenness centralization) to sustainability capacity

While the previous section assessed the interconnectedness of the networks, this analysis is also informed through understanding the hierarchical nature of the networks. Table 19 presents the betweenness centralization scores for the contact networks, any communication networks, and information seeking for each site along with their CSAT score. High betweenness centralization scores indicate communication structures that are more hierarchical, and with a small number of network members who are in positions where than can control the flow of information across the network. Overall, betweenness centralization
varies across the nine hospital sites; for example, Site 9 shows the highest centralization for contact (.23), while Site 6 has the lowest (.10). In addition, there are lower betweenness centralization scores for information seeking than the other two networks, indicating there are not singular individuals who are sought out for information. There is slightly more hierarchical structure in the contact networks and even more for any communication. This suggests that while individuals might contact a variety of people for clinical care, there are individuals who are more clearly leaders in the communication networks.

<table>
<thead>
<tr>
<th></th>
<th>CSAT Score</th>
<th>Betweenness Centralization - Contact</th>
<th>Betweenness Centralization – Any Communication</th>
<th>Betweenness Centralization – Information Seeking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>5.05</td>
<td>0.11</td>
<td>0.11</td>
<td>0.04</td>
</tr>
<tr>
<td>Site 1</td>
<td>4.58</td>
<td>0.13</td>
<td>0.24</td>
<td>0.12</td>
</tr>
<tr>
<td>Site 3</td>
<td>4.90</td>
<td>0.13</td>
<td>0.15</td>
<td>0.08</td>
</tr>
<tr>
<td>Site 4</td>
<td>4.55</td>
<td>0.17</td>
<td>0.33</td>
<td>0.06</td>
</tr>
<tr>
<td>Site 5</td>
<td>5.21</td>
<td>0.16</td>
<td>0.17</td>
<td>0.11</td>
</tr>
<tr>
<td>Site 6</td>
<td>5.49</td>
<td>0.10</td>
<td>0.15</td>
<td>0.03</td>
</tr>
<tr>
<td>Site 7</td>
<td>4.68</td>
<td>0.12</td>
<td>0.18</td>
<td>0.09</td>
</tr>
<tr>
<td>Site 8</td>
<td>5.40</td>
<td>0.18</td>
<td>0.22</td>
<td>0.06</td>
</tr>
<tr>
<td>Site 9</td>
<td>4.67</td>
<td>0.23</td>
<td>0.20</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Table 19. CSAT score and betweenness centralization scores for each site

Figures 21, 22, and 23 show the associations between the three betweenness centralization scores and the overall CSAT scores. There is a moderate, negative correlation between the contact network betweenness centralization and CSAT score. There are larger, negative correlations between the communication and information seeking betweenness centralization scores and overall CSAT score. This illustrates that those sites that have lower betweenness scores, which indicate a flatter communication structure, have higher
sustainability capacity. This is especially true in the information seeking and communication networks. These are not statistically significant due to a small sample size.

Figure 21. Relationship of betweenness centralization score for contact networks and overall CSAT score.
Figure 22. Relationship of betweenness centralization score for communication networks and overall CSAT score
Figure 23. Relationship of betweenness centralization score for information seeking networks and overall CSAT score

**Discussion**

This study explored the social networks of surgeons and antimicrobial stewardship teams with regards to evidenced-based care in surgical antibiotic prescribing. It found that both overall contact networks and the different communication networks vary based on the site. Most communication occurs in the context of clinical care where immediate patient decisions are made. Antimicrobial stewards have different levels of prestige across hospitals and often are focused on collaboration outside of their immediate team. Finally,
the most intriguing findings are that communication structures might be related to sustainability capacity in these hospitals.

*Networks of antimicrobial stewards and surgical teams*

While surgeons have set procedures, teams, and sometimes units of practice, antimicrobial stewards move more fluidly in and out of different settings. In this sense, stewards act as knowledge brokers and are able to assist in disseminating information across settings. However, their influence is, in many ways, dependent on the willingness of individuals to rely on them and use them as part of their network. A network study in pediatric emergency departments found that knowledge-sharing networks can be strengthened, which increases access to knowledge about evidence-based care and can increase practice changes and support quality care delivery [152]. This study would support the idea that networks can vary in strength, which indicates that finding ways to increase the antimicrobial stewardship centrality would ultimately benefit the delivery of evidence-based care in pediatric surgical settings.

Additionally, a review of network analysis in healthcare providers found that the types of patients and practice setting increase the social ties between providers which ultimately improve care coordination and patient outcomes [138]. This study finds similar patterns, supporting the notion that stronger social ties amongst similar providers increases the uptake of guideline-concurrent care. In antimicrobial stewardship, the relationships that must be built are unique in that they require relationship-building across patient types, professional training, and team structures.
Teams, power, and sustainability

The study assessed the overall interconnectedness of networks as well as the betweenness centralization, a measure representing the hierarchy in the network. The densities of the networks varied but there were consistent patterns of teams forming relationships in the various sites. Overall clinical communication networks show a fairly high degree of teamwork, or cross specialty communication. However, there were fewer ties within the other types of communication. There are opportunities to consider how teams are formed to work on system level initiatives and organizational planning.

Historically, hospitals and clinical settings have been criticized for their hierarchical nature. This study only assessed the hierarchy amongst physicians and found that there were fairly low levels of hierarchical communication around surgical prescribing, as measured through the betweenness centralization scores. This might have been different if all professionals were included in these networks or the questions were being asked about a different type of clinical care. More equal networks also had higher sustainability scores, suggesting that building a network where people are treated as equals ultimately improves the quality of healthcare delivery.

A couple of study design limitations are important to keep in mind while interpreting these results. First, this was a self-report survey with lower response rates from non-stewardship team participants, which means that there are limitations in the interpretations that can be made from the data. While antimicrobial stewardship teams had a perfect response rate, this concern about interpretation is especially true for any non-stewardship team members, which had lower response rates across all sites. Furthermore, while the relational findings from the second research question are very intriguing, they are provisional. The effect sizes are strong and consistent across the tie types and networks, but the small number of hospitals means that more research is required with larger sample sizes. This will allow us to understand if these findings are replicated across the larger studies.
Relationship of social structure and sustainability

This study used a conceptual framework assessing how network structures ultimately lead to sustainability capacity. However, many theories of systems include an understanding that the system is dynamic and that different factors create feedback loops [153-155]. Systems dynamics would conceptualize this loop as reinforcing, meaning that one variable increase drives the other, which, in turn, feeds back and further drive the first variable. The research in this field would suggest that a useful theory would be one where positive communication structure and sustainability capacity continue to influence each other, as depicted in Figure 24. The feedback remains situated within other important context factors – for example, resources would still play a large impact on the relationship. This would warrant further exploration and testing.

Figure 24. Hypothesized relationship between sustainability capacity and communication structure
Use of network methods in implementation science

A prior systematic review of network analysis in health found that, like this study, most network analysis has been descriptive of the network [156]. While descriptive network analysis provides useful information about spread and communication structures, future research should use this information to develop interventions and evaluate implementation initiatives [156]. Additionally, qualitative and mixed methods studies should be designed to provide additional information in engagement of clinicians, especially to understand more detail about how engagement occurs.

This study suggests that there is a relationship between the communication structures in a network and the organizational capacity to sustain evidence-based practices. Understanding this relationship more fully could illuminate an opportunity to influence change and ultimately increase evidence-based care delivery in these complicated organizations. Future work in this area should focus on gathering data that would allow for testing network models.
Chapter 5: Conclusion & Implications
Dissertation Results & Conclusions

This dissertation responds to an important need and answers questions about contextual and structural factors that influence sustainability within pediatric care settings. The results reported here are relevant to health research, implementation science, clinical practice, and policy. Furthermore, this work helps to further validate relatively new concepts and assessment methods of capacity for clinical sustainability. This work builds a foundation for future research to understand how to create environments that are best prepared to reliably and sustainably deliver high-quality health care to all patients.

Study-specific Findings

Sustainability in pediatric healthcare settings was assessed through the three interrelated studies. Study one examined determinants of clinical sustainability, specifically seeking to understand the influence of quality improvement on sustainability in hospital settings. The analyses found that sustainability capacity is influenced by a few factors, including the perception of evidence, individual roles, frequency of delivery, and quality improvement capabilities of the setting. The clinical sustainability assessment framework provides insight into the different determinants of sustainability.

Study two validated the concept of sustainability through the viewpoints and experiences of clinicians. Through a series of in-depth interviews, information about the experience and knowledge of frontline providers was revealed regarding sustainability and sustainment of practices in healthcare. Further, these interviews highlighted the contextual nuances regarding workflow, stakeholder engagement, and prioritization that need to be understood in order to improve sustainment in complex healthcare settings.

Study three explored the structural aspects of the hospital setting and how they relate to sustainability capacity. Specifically, social network analysis was used to visualize and describe different patterns of
communication structures within a set of hospitals implementing evidence-based antimicrobial stewardship programs. In addition to the network measure, the Clinical Sustainability Assessment Tool was used to measure sustainability capacity for the stewardship programs within these settings. There were patterns in communication across different subgroups. Hospitals had different densities of communication patterns and accessed the expertise of antimicrobial stewards with different frequency. Additionally, the network analysis revealed that communication structures that are stronger and less hierarchical increase sustainability capacity.

Results Integration

Together, these aims advance the validation of sustainability measurement and highlight how structural and contextual factors lead to or detract from a program’s ability to be sustained in clinical settings. Figure 25 illustrates the overall learning from the combinations of each aim as well as within the overall dissertation. Studies one and two both inquired about determinants of sustainability capacity. Quality improvement capabilities increase sustainability, although a lot of the responsibilities for this came from the responsibilities of individual clinicians. Study two and three, taken together, highlight the importance of understanding both individual roles as well as the collective networks within clinical settings. Studies two and three highlight the value of using both survey methods and systems science to understand a research topic. The network insights aid in understanding how staff engagement might function in a setting to increase sustainability capacity.

Overall, the findings of the dissertation illuminate the importance of better understanding individual clinician contributions to sustainability as well as the impact of social systems within and across hospital teams. Taken together, the dissertation helps us understand the relevant factors that lead to sustainability and help develop our knowledge of constructs that contribute to sustainability measurement.
Implications for the Field

This dissertation informs implementation science in two major ways: through the advancement of sustainability research and through some theoretical work targeted at the intersection of quality
improvement and implementation science. Additionally, this work has implications for clinical care delivery.

Implications for Implementation Science

Sustainability validation

Multiple reviews have been conducted to assess literature about program and practice sustainability and sustainment [7, 8, 157]. While most of those have focused on fields outside of clinical health care, they all highlighted the need for a consensus on defining sustainability and to move forward in understanding determinants prior to developing interventions. This study is responsive to the state of the field and targeted understanding determinants of sustainability within hospital care delivery. This dissertation also further helps validate the Clinical Sustainability Assessment Tool. Aim 1 discovered that the significant predictors of sustainability were intervention and organization-level characteristics as opposed to individual factors.

The studies, taken together, create questions about how stakeholders are defined and chosen in clinical settings. While traditionally this might consist of context experts, the network analysis indicated that clinicians do not always seek information from content experts and instead seek people that are either in their subgroup or who are conveniently accessible. These studies also highlight the role of social influence and the provider to create a context that is amiable to sustainability.

While all seven domains with the sustainability framework were relevant to clinicians, the other major predictors of sustainability capacity were routinization into the workflow and perception of the strength of evidence. This is especially interesting in pediatrics, where much of the evidence is adapted from adult care settings. However, these are areas for future exploration. The combination of the importance of social
influence and perception of evidence might be useful to explore further, as it would create a relatively easy intervention target. Applying this framework to continue to study sustainability determinants can aid in ultimately improving the ability to continue to deliver evidence-based care. Future work in this area could focus on predictive validity of the measure in addition to understanding the usefulness of an even briefer tool for clinicians.

**Intersection of quality improvement and implementation science**

Mitchell and Chambers (2017) address the overlap of quality improvement, health services research, and implementation science in their work advocating for more implementation science within cancer care [96]. In their work, implementation science and quality improvement are nested within health services research. However, this understanding proves insufficient considering the different historical development, approaches to improvement, and orientation to healthcare improvement. Further, other researchers have merely suggested that quality improvement and implementation science are more alike than different, but that each simply uses different terminology and jargon [158, 159]. This dissertation asked a question about the ways that these two fields relate to each other and concluded that quality improvement structures, although using discrete tools, ultimately change the context or approach to care delivery. Further, providers describe this ‘culture of quality’ when they think about approaches their institution has adopted to improve. It follows, then, that beginning to describe these two fields should begin with exploring their approach to measuring and influencing context. This aligns with the concepts of enabling conditions, which are the organizational characteristics that must be present [90]. This dissertation reveals the interplay between assessing for context and the ability to change the organizational environment with regard to the demand for evidence-based care delivery.
One of the focuses of implementation science is on the context and recognizing that the implementation effort must match the environmental context. Sustainability capacity is the area of sustainability research that operationalizes the congruence with the organizational environment. Most qualitative work around implementation has focused on the context, barriers, and enablers for initial implementation efforts [160, 161]. While this work does not compare the context for initial implementation with relevant factors for sustainment, it is likely that there is overlap between the two processes. Further understanding of how quality improvement structures influence the overall clinical environment could aid in developing interventions for sustainability in hospital settings.

**Bridging factors as an emerging concept for sustainability**

This dissertation ultimately examined the importance of numerous determinants of sustainability that exist at different levels of influence. For example, individual factors and behaviors are more of an inner setting influence whereas institutional policies, medical records, and system financial support would be considered more in the outer setting.

Implementation science literature has adopted a consensus understanding of inner and outer context and used it to develop frameworks about how the organizational context can be best articulated and studied [54, 67]. The Exploration, Preparation, Implementation, Sustainment framework (EPIS) has developed the concept of bridging factors to describe the things that exist as intermediaries between these settings [53]. Within health care settings, the inner and outer settings are not as distinct as in other organizational spheres. The healthcare system, or organization, can function as another setting level. Each hospital unit has an individual team that can have a very different context than its neighboring unit, even if some of the actors cross both settings and are all enveloped under a single hospital entity. Thus, this concept of bridging factors should also be applied to these different environments within hospital settings. This is
important because many of the determinants that were highlighted in the dissertation do create an interface between these different contexts, therefore acting in the same manner that bridging factors have been theorized. For instance, knowledge brokers like antimicrobial stewards do not exist in a single unit or setting, and therefore act as bridging factors who move across different units and teams. Additionally, the electronic medical record is a bridging factor, as it is developed at a system level but interfaces with individual providers at the bedside. The interplay between the individuals and the medical record has huge implications for standard practice and has the ability to influence each other. Uncovering these bridging factors – their measurement, role, and impact, will aid in a better understanding of the care delivery system. These bridging factors need to be considered theoretically as well as for their effectiveness and feasibility in practice. For example, these could potentially be expensive or additionally resource burdened in real-world settings.

*Implications for Healthcare Delivery*

In the area of clinical quality improvement, this research on sustainability practices can help develop programs that better plan for and measure the sustainability of other evidence-based programs. These clinical services can be improved by better understanding different dimensions of their programs. Ultimately, understanding this contextual information can aid in how academic medical centers understand their own site and how to consider complex interactions between people, workflow, and evidence-based practice.

One of the ideas that emerged in the qualitative analysis was the concept of provider burden. This is not something that is often assessed for but could have a relevant interplay with the implementation of evidence-based care. For example, an intervention that a provider perceives as not important but has a high burden would be less likely to be implemented than one that is comparatively ‘easy’ for a provider to
deliver. This is especially true in times of high demand or less time, requiring choices to be made about which interventions to prioritize.

The findings regarding which provider perceptions influence sustainability capacity can inform how implementers, facilitators, and champions design program and practice changes. Ideally, these findings could also help design care systems that are more responsive to frontline provider concerns and opinions. Ultimately, this will also help reduce the burnout that is currently causing major labor shortages within clinical care. Using pragmatic, valid measures for evaluation and planning will help improve care delivery while also reducing the burden in designing implementation and sustainability plans.

**Limitations and Future Research**

All three of these studies relied on the voluntary contributions of frontline clinicians, both through survey and interview methods. This is important to remember when considering all of the results, although is most critical due to a low response rate in the network analysis. This study, however, was exploratory and was not attempting to determine any causal relationships. Additionally, this study focused on settings that have a lot of resources and are academic medical centers. For many hospitals both within the United States and globally, many of these findings and principles would play out differently. For instance, there are different quality improvement experiences, personnel demands, and other setting factors that would influence sustainability.

The most advantageous next steps for sustainability research would be the development of prospective studies to assist in defining sustainability and understanding the relative importance of different constructs in their contribution to sustainability capacity. Further, research needs to be targeted at developing and testing strategies to increase sustainability and sustainment. This dissertation also highlights the need to
continue to explore both individual actors within the healthcare system as well as the networks that are created. The dissertation also supports ways that systems science theory and methods can inform implementation science [62].

Personally, I plan to use this dissertation as a starting point to develop a research and evaluation career focusing on healthcare improvement through evidence-based practice delivery. This will help shape future studies that focus on systems science and the sustainment of care delivery in complex, overburdened settings. I hope to have a career that is centered in the same areas that this dissertation will impact: implementation science research, clinical quality, and health care delivery. I am interested in developing a research program that assists both researchers and clinicians develop practical interventions to deliver high-quality care to more patients. Ultimately, this will lead to a career focused on improving the health care systems that serve children.

**Final Conclusions**

Children’s hospitals are necessary to focus on the unique needs of all children and their families. These care delivery settings have focused on understanding diseases of childhood, but also serve as a delivery hub with unique multidisciplinary teams [70]. Over time, these systems have gotten both more important and more complex, with millions of children accessing care in this setting each year. Further, these teams have a unique opportunity to impact health over the entire lifespan due to the unique trajectory of pediatric care and morbidities of childhood illness [162]. Together, all of these unique factors emphasize the importance of ensuring high-quality care delivery in these settings.

Implementation science has focused on delivering high-quality care through understanding translational principles and the importance of matching interventions to their context. The context of clinical care
settings, and more specifically pediatrics, is one that is increasingly complex but includes teams of motivated, passionate, and driven individuals. These settings often adopt new interventions and aim to improve care delivery as new evidence becomes available. However, there still remain real delays in the implementation of evidence-based care and sustainability of interventions that get adopted into these delivery settings.

These dissertations studies have focused on understanding the determinants of sustainability in hospital settings. The history of quality improvement in these clinical settings is significant and influences the capacity for sustainability. As standard care has become the emphasis for effective and efficient care, the emphasis on care improvement has been on workflows that stress the removal of individual behaviors [163, 164]. However, this study highlighted the ways that providers have unique roles and experiences at the bedside. Appreciating these individual insights and behaviors is vital to creating a context that enables sustainability. Further, individuals develop significant structural relationships that influence knowledge acquisition and ultimately behaviors around evidence-based care delivery. Understanding these relationships and how they influence care delivery can help design systems that can both reliably and continuously implement and sustain the highest quality care for the most vulnerable children. This study has highlighted determinants of sustainability in pediatric healthcare – suggesting a future in developing interventions to improve ongoing care.


90. Easterling, D., et al., Clarifying the concept of a learning health system for healthcare delivery organizations: Implications from a qualitative analysis of the scientific literature. Learning Health Systems. n/a(n/a): p. e10287.


Palinkas, L. and D. Zatzick, *Rapid Assessment Procedure Informed Clinical Ethnography (RAPICE) in Pragmatic Clinical Trials of Mental Health Services Implementation: Methods and Applied Case Study*. Administration and Policy in Mental Health and Mental Health Services Research, 2018. 46.


Appendix A: Clinical Sustainability Assessment Tool

What is clinical sustainability capacity?
We define clinical sustainability capacity as the ability of an organization to maintain structured clinical care practices over time and to evolve and adapt these practices in response to new information.

Why is clinical sustainability capacity important?
Without sustaining effective practices over time, we risk not being able to see the full return on our nation’s investment in clinical and translational science. Successful implementation of new practices in clinical or healthcare settings is affected by a number of organizational, financial, regulatory, and political factors. To maintain these benefits, clinical settings and healthcare organizations must support these clinical practices in a number of ways. With knowledge of these critical factors, stakeholders can build capacity for sustainability of a clinical practice and position their efforts for long term success.

What is the purpose of this tool?
This tool will help structure an assessment of your group’s current capacity for sustainability across a range of specific organizational and contextual factors. Your responses will identify sustainability strengths and challenges. You can then use results to guide sustainability action planning for your clinical practice.

Helpful definitions
The Clinical Sustainability Assessment Tool can be used in a wide variety of clinical practice settings. Before starting the assessment, you should identify the specific clinical practice you will be assessing.

Below are a few definitions of terms that are frequently used throughout the tool.

Practice refers to the set of formal organized activities that you want to sustain over time. Such activities could occur in a variety of clinical settings.

Organization encompasses all the parent organizations or agencies in which the practice is housed. Depending on the practice, the organization may refer to a health center, a hospital, etc.

Community refers to the stakeholders who may benefit from or who may guide the practice. This could include clinical staff, leadership, care recipients and their families, etc. Community does not refer to a specific town or neighborhood.
The next question is to serve as a reference point for the following survey. Some examples of clinical practices are: antibiotic stewardship, a new surgical procedure, electronic medical record order sets, or hand hygiene.

*The name of the practice or set of activities I am assessing is:*

In the following questions, you will rate your practice across a range of specific factors that affect sustainability. Please respond to as many items as possible. If you truly feel you are not able to answer an item, you may select “NA.” For each statement, circle the number that best indicates the extent to which your practice has or does the following things.

**Engaged Staff & Leadership:** Having supportive frontline staff and management within the organization

<table>
<thead>
<tr>
<th></th>
<th>To little or no extent</th>
<th>To a very great extent</th>
<th>Not able to answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The practice engages leadership and staff throughout the process.</td>
<td>1 2 3 4 5 6 7</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>2. Clinical champions of the practice are recognized and respected.</td>
<td>1 2 3 4 5 6 7</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>3. The practice has engaged, ongoing champions.</td>
<td>1 2 3 4 5 6 7</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>4. The practice has a leadership team made of multiprofessional partnerships.</td>
<td>1 2 3 4 5 6 7</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>5. The practice has team-based collaboration and infrastructure.</td>
<td>1 2 3 4 5 6 7</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>
For each statement, circle the number that best indicates the extent to which your practice has or does the following things.

**Engaged Stakeholders**: Having external support and engagement for the practice.

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The practice engages the patient and family members as stakeholders.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>2. There is respect for all stakeholders involved in the practice.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>3. The practice is valued by a diverse set of stakeholders.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>4. The practice engages other medical teams and community partnerships as</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>appropriate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. The practice team has the ability to respond to stakeholder feedback</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>about the practice.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Organizational Readiness**: Having the internal support and resources needed to effectively manage the practice

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Organizational systems are in place to support the various practice</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>needs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The practice fits in well with the culture of the team.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>3. The practice has feasible and sufficient resources (e.g., time, space,</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>funding) to achieve its goals.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For each statement, circle the number that best indicates the extent to which your practice has or does the following things.

**Workflow Integration:** Designing the practice to fit into existing practices and technologies

<table>
<thead>
<tr>
<th></th>
<th>To little or no extent</th>
<th>To a very great extent</th>
<th>Not able to answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. The practice has adequate staff to achieve its goals.</td>
<td>1 2 3 4 5 6 7 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. The practice is well integrated into the operations of the organization</td>
<td>1 2 3 4 5 6 7 NA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Implementation & Training:** Using processes that guide the direction, goals and strategies of the practice

<table>
<thead>
<tr>
<th>1. The practice clearly outlines roles and responsibilities for all staff.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. The reason for the practice is clearly communicated to and understood by all staff.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>3. Staff receive ongoing coaching, feedback, and training.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>4. Practice implementation is guided by feedback from stakeholders.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>5. The practice has ongoing education across professions.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Monitoring & Evaluation:** Assessing the practice to inform planning and document results

| 1. The practice has measurable process components, outcomes, and metrics. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | NA |
| 2. Evaluation and monitoring of the practice are reviewed on a consistent basis. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | NA |
| 3. The practice has clear documentation to guide process and outcome evaluation. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | NA |
| 4. Practice monitoring, evaluation, and outcomes data are routinely reported to the clinical care team. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | NA |
| 5. The practice process components, outcomes, and metrics are easily assessed and audited. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | NA |
Outcomes & Effectiveness: Understanding and measuring practice outcomes and impact

<table>
<thead>
<tr>
<th></th>
<th>To little or no extent</th>
<th>To a very great extent</th>
<th>Not able to answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The practice has evidence of beneficial outcomes.</td>
<td>1 2 3 4 5 6 7 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The practice is associated with improvement in patient outcomes that are clinically meaningful.</td>
<td>1 2 3 4 5 6 7 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The practice is clearly linked to positive health or clinical outcomes.</td>
<td>1 2 3 4 5 6 7 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The practice is cost-effective.</td>
<td>1 2 3 4 5 6 7 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. The practice has clear advantages over alternatives.</td>
<td>1 2 3 4 5 6 7 NA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Appendix B: Clinical Sustainability Assessment Tool Validation Survey

Intervention

The following questions will ask about the clinical practice or set of activities you are assessing.

1. Please rate the strength of the scientific evidence supporting your clinical practice.
   a. Very weak
   b. Weak
   c. Neither weak nor strong
   d. Strong
   e. Very strong
   f. Don’t know/NA

2. Approximately how long has the practice been implemented at your workplace?
   a. Less than 1 year
   b. 1 – 2 years
   c. 3 – 5 years
   d. 6-10 years
   e. Greater than 10 years
   f. Don’t know

3. How important is the clinical practice to provide quality care to your patient population?
   a. Not at all important
   b. Somewhat unimportant
   c. Neither important nor unimportant
   d. Somewhat important
4. How achievable was or is this clinical practice to implement within your organization?
   a. Very difficult
   b. Somewhat difficult
   c. Neither easy nor difficult
   d. Somewhat easy
   e. Very easy

5. Regarding patients under my care, they can expect to receive this intervention
   a. None of the time
   b. Some of the time
   c. Most of the time
   d. All of the time

**Organization**

The following questions will ask about your organization and environment in which you work.

6. To the best of your knowledge, how many clinical staff are employed in your organization?
   a. less than 50
   b. 50 – 249
   c. 250 +
7. Which of the following best describes your clinical work environment?
   a. Academic hospital
   b. Community hospital
   c. Private hospital
   d. Community Health Center
   e. Ambulatory care
   f. Urgent care
   g. Clinic (private practice)
   h. Nursing home
   i. Other (please specify): ____________________________

8. Which of the following best describes your place of work?
   a. Urban
   b. Suburban
   c. Rural
Please indicate how much you agree or disagree with each of the following statements.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither agree nor disagree</th>
<th>Somewhat agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Our resources (personnel, time, financial) are too tightly limited to improve care quality now.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. Our clinical team understands and uses quality improvement skills effectively.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. Our clinical team has changed or created systems in the organization that make it easier to provide high quality care.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. We choose new processes of care that are more advantageous than the old to everyone involved (patients, clinicians, and our entire clinical team).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. The working environment in our clinical team is collaborative and cohesive, with shared sense of purpose, cooperation, and willingness to contribute to the common good.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. Our clinical team has greatly improved quality of care in the past year.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Participant**

The following questions will ask about your work. Please indicate your response for each question or statement.

13. What is your primary service setting?
   a. Inpatient
   b. Outpatient
   c. Both inpatient and outpatient
   d. N/A – Does not apply to my work

14. What population do you primarily work with?
   a. Adult
b. Pediatrics

c. Both adult and Pediatrics

d. N/A – Does not apply to my work

15. What is your primary profession?

a. Advanced Practice Provider/Nurse Practitioner

b. Behavioral Health

c. Healthcare Administration

d. Nurse

e. Oral health

f. Pharmacist

g. Physician

h. Psychologist

i. Public health

j. Rehabilitation specialist: physical/occupational therapist

k. Rehabilitation specialist: speech/music/art/child life/education

l. Researcher

m. Respiratory Therapist

n. Social work

o. Other (please list): ____________________________

16. What is your primary current position?

a. Bedside provider/ direct patient care

b. Leadership/management

c. Administrative

d. Research

e. Other (please specify): ____________________________

17. In relation to the clinical practice, what is your primary role?
a. Leading (e.g., point person or champion)
b. Administration
c. Participating
d. Evaluator
e. Clinical staff
f. Other _____________________________
Appendix C: Model Output – Quality Improvement Score and each CSAT Domain

Engaged Staff

EStfmod<-lmer(EStf~factor(SettingNew)+factor(PositionNew)+factor(ProfNew)+factor(EnvNew)+ factor(RoleNew) + InterventionLengthCNT + factor(Important) + EvidenceCNT + AchievCNT + FreqCNT + QITotal + (1|Site), data=CSAT5)
summary(EStfmod)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [## lmerModLmerTest]
## Formula: EStf ~ factor(SettingNew) + factor(PositionNew) + factor(ProfNew) +
##      factor(EnvNew) + factor(RoleNew) + InterventionLengthCNT +
##      factor(Important) + EvidenceCNT + AchievCNT + FreqCNT + QITotal +
##      (1 | Site)
## Data: CSAT5
##
## REML criterion at convergence: 541.7
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.0279 -0.4000  0.2153  0.6530  1.7546
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept) 0.08168  0.2858
##  Residual             1.06532  1.0321
## Number of obs: 180, groups: Site, 30
##
## Fixed effects:
##                  Estimate Std. Error df  t value Pr(>|t|)
## (Intercept)       1.158473  0.860687 150  1.346  0.18033
## factor(SettingNew)2  0.017331  0.202215 151  0.086  0.93181
## factor(PositionNew)2  0.216140  0.216234 151  1.000  0.31900
<table>
<thead>
<tr>
<th>Term</th>
<th>Coefficient 1</th>
<th>Coefficient 2</th>
<th>Coefficient 3</th>
<th>Coefficient 4</th>
<th>Coefficient 5</th>
<th>Coefficient 6</th>
<th>Coefficient 7</th>
<th>Coefficient 8</th>
<th>Coefficient 9</th>
<th>Coefficient 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>factor(ProfNew)2</td>
<td>0.332955</td>
<td>0.265032</td>
<td>157.118692</td>
<td>1.256</td>
<td>0.21088</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>factor(ProfNew)3</td>
<td>0.158695</td>
<td>0.268379</td>
<td>162.729475</td>
<td>0.591</td>
<td>0.55513</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>factor(EnvNew)2</td>
<td>0.005080</td>
<td>0.265342</td>
<td>142.166573</td>
<td>0.019</td>
<td>0.98475</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>factor(RoleNew)2</td>
<td>-0.008313</td>
<td>0.343582</td>
<td>162.289929</td>
<td>-0.024</td>
<td>0.98073</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>factor(RoleNew)3</td>
<td>-0.253321</td>
<td>0.227046</td>
<td>162.945821</td>
<td>-1.116</td>
<td>0.26618</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>factor(RoleNew)4</td>
<td>-0.839960</td>
<td>0.491248</td>
<td>161.793462</td>
<td>-1.710</td>
<td>0.08921</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>factor(RoleNew)5</td>
<td>-0.333125</td>
<td>0.227352</td>
<td>160.729154</td>
<td>-1.465</td>
<td>0.14481</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InterventionLengthCNT</td>
<td>0.034476</td>
<td>0.096217</td>
<td>98.722293</td>
<td>0.358</td>
<td>0.72087</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>factor(Important)4</td>
<td>-0.236690</td>
<td>0.366586</td>
<td>159.835108</td>
<td>-0.646</td>
<td>0.51942</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>factor(Important)5</td>
<td>-0.244610</td>
<td>0.293758</td>
<td>157.318679</td>
<td>-0.833</td>
<td>0.40628</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EvidenceCNT</td>
<td>0.344690</td>
<td>0.125202</td>
<td>162.983282</td>
<td>2.753</td>
<td>0.00657 **</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AchievCNT</td>
<td>-0.010521</td>
<td>0.104401</td>
<td>162.120857</td>
<td>-0.101</td>
<td>0.91985</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FreqCNT</td>
<td>0.280865</td>
<td>0.116788</td>
<td>158.229273</td>
<td>2.405</td>
<td>0.01733 *</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QITotal</td>
<td>0.493534</td>
<td>0.151508</td>
<td>151.877078</td>
<td>3.257</td>
<td>0.00139 **</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation matrix not shown by default, as p = 17 > 12.

Use print(x, correlation=TRUE) or

vcov(x) if you need it
Engaged Stakeholder

```
Estmod<-lmer(EStk~factor(SettingNew)+factor(PositionNew)+factor(ProfNew)+factor(EnvNew)+ factor(RoleNew) + InterventionLengthCNT + factor(Important) + AchievCNT + EvidenceCNT + FreqCNT + QITotal + (1|Site), data=CSAT5)

summary(Estmod)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [1merModLmerTest]
## Formula: EStk ~ factor(SettingNew) + factor(PositionNew) + factor(ProfNew) +
## factor(EnvNew) + factor(RoleNew) + InterventionLengthCNT +
## factor(Important) + AchievCNT + EvidenceCNT + FreqCNT + QITotal +
## (1 | Site)
## Data: CSAT5
##
## REML criterion at convergence: 564.7
##
## Scaled residuals:
##     Min 1Q Median 3Q Max
## -3.7518 -0.5506 0.1320 0.5878 1.7410
##
## Random effects:
## Groups     Name        Variance Std.Dev.
## Site       (Intercept) 0.1376   0.3709
## Residual               1.2041   1.0973
## Number of obs: 180, groups: Site, 30

## Fixed effects:
##                     Estimate Std. Error   df   t value Pr(>|t|)
## (Intercept)        1.575345   0.929439 153.278871 1.695 0.0921 .
## factor(SettingNew)2 0.105360   0.217490 161.900146 0.484 0.6287
## factor(PositionNew)2 0.247883   0.231870 162.493600 1.069 0.2866
## factor(ProfNew)2   -0.144866   0.285451 157.028926 -0.507 0.6125
## factor(ProfNew)3    0.171802   0.288041 160.860895 0.596 0.5517
## factor(EnvNew)2     0.261818   0.286654 157.028926 0.913 0.3625
## factor(RoleNew)2    0.094782   0.367968 160.968638 0.258 0.7971
```
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Correlation matrix not shown by default, as p = 17 > 12.

## Use print(x, correlation=TRUE) or

## vcov(x) if you need it
Organizational Readiness

Orgmod<-lmer(Org~factor(SettingNew)+factor(PositionNew)+factor(ProfNew)+factor(EnvNew)+ factor(RoleNew) + InterventionLengthCNT + factor(Important) + AchievCNT + EvidenceCNT + FreqCNT + QITotal + (1|Site), data=CSAT5)
summary(Orgmod)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [lmerModLmerTest]

## Formula: Org ~ factor(SettingNew) + factor(PositionNew) + factor(ProfNew) +
##     factor(EnvNew) + factor(RoleNew) + InterventionLengthCNT +
##     factor(Important) + AchievCNT + EvidenceCNT + FreqCNT + QITotal +
##     (1 | Site)
##    Data: CSAT5

## REML criterion at convergence: 485.9

## Scaled residuals:
##    Min      1Q  Median      3Q     Max
## -3.5374  -0.4657  0.1403  0.5909  2.9377

## Random effects:
## Groups   Name        Variance Std.Dev.
## Site     (Intercept) 0.1160   0.3405
## Residual             0.7544   0.8686
## Number of obs: 178, groups: Site, 30

## Fixed effects:
##                  Estimate Std. Error    df  t value Pr(>|t|)
## (Intercept)    -0.479570   0.746486 153.4954 -0.642  0.521548
## factor(SettingNew)2  0.009155   0.176532 160.3265   0.052  0.958706
## factor(PositionNew)2  0.098240   0.185286 159.4164   0.530  0.596708
## factor(ProfNew)2     0.428930   0.229053 160.8124   1.873  0.062936 .
## factor(ProfNew)3     0.476297   0.231347 159.0228   2.059  0.041145 *
## factor(EnvNew)2      0.218068   0.235969 159.4079   0.924  0.356812
## factor(RoleNew)2     0.219707   0.293345 157.0147   0.749  0.454996
## factor(RoleNew)3
-0.122535   0.194778 159.050660 -0.629 0.530185
## factor(RoleNew)4
-0.440926   0.421764 160.920261 -1.045 0.297390
## factor(RoleNew)5
-0.228633   0.195837 160.783955 -1.167 0.244753
## InterventionLengthCNT
-0.025931   0.085353 109.508627 -0.304 0.761846
## factor(Important)4
-0.298667   0.316719 153.752461 -0.943 0.347158
## factor(Important)5
-0.567319   0.255127 150.188922 -2.224 0.027663 *
## AchievCNT
0.325285   0.090865 160.999827  3.580 0.000455 **
## EvidenceCNT
0.282701   0.108070 159.425418  2.616 0.009754 **
## FreqCNT
0.077332   0.101379 158.740055  0.763 0.446717
## QITotal
0.869780   0.132556 158.272109  6.562  7.2e-10 **

## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Correlation matrix not shown by default, as p = 17 > 12.

## Use print(x, correlation=TRUE) or
## vcov(x) if you need it
Workflow Integration

```r
WorkIntmod<-
lmer(WorkInt~factor(SettingNew)+factor(PositionNew)+factor(ProfNew)+
+factor(EnvNew)+factor(RoleNew) + InterventionLengthCNT + factor(Important)
+ EvidenceCNT + AchievCNT + FreqCNT + QITotal + (1|Site), data=CSAT5)
summary(WorkIntmod)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method
## lmerModLmerTest
## Formula:
## WorkInt ~ factor(SettingNew) + factor(PositionNew) + factor(ProfNew) +
##    factor(EnvNew) + factor(RoleNew) + InterventionLengthCNT +
##    factor(Important) + EvidenceCNT + AchievCNT + FreqCNT + QITotal +
##    (1 | Site)
## Data: CSAT5
##
## REML criterion at convergence: 500.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.3773 -0.5532  0.0658  0.7302  2.5877
##
## Random effects:
## Groups   Name        Variance Std.Dev.
## Site     (Intercept) 0.09465  0.3077
## Residual             0.83973  0.9164
## Number of obs: 178, groups: Site, 30
##
## Fixed effects:
##                     Estimate Std. Error   df  t value Pr(>|t|)
## (Intercept)     0.170579   0.776616 151.236843  0.220 0.826444
## factor(SettingNew)2 -0.178406   0.184253 159.657038 -0.968 0.334375
## factor(PositionNew)2 0.277041   0.194009 160.474503  1.428 0.155241
## factor(ProfNew)2    0.324781   0.239114 159.217944  1.358 0.176300
## factor(ProfNew)3    0.415125   0.242239 160.688772  1.714 0.088509.
## factor(EnvNew)2     0.158344   0.245825 151.704189  0.644 0.520462
```
## factor(RoleNew)2 $0.008268$ $0.307518$ $158.963022$ $0.027$ $0.978585$
## factor(RoleNew)3 $-0.114369$ $0.203987$ $160.324430$ $-0.561$ $0.575806$
## factor(RoleNew)4 $-0.395558$ $0.440896$ $160.877855$ $-0.897$ $0.370970$
## factor(RoleNew)5 $0.161150$ $0.204491$ $160.018223$ $0.788$ $0.431832$
## InterventionLengthCNT $0.006023$ $0.087946$ $104.338610$ $0.068$ $0.945532$
## factor(Important)4 $-0.117980$ $0.332455$ $155.770592$ $-0.355$ $0.723162$
## factor(Important)5 $-0.157048$ $0.268072$ $152.855432$ $-0.586$ $0.558846$
## EvidenceCNT $0.392350$ $0.113145$ $160.655089$ $3.468$ $0.000674$ **
## AchievCNT $0.109235$ $0.094955$ $160.786173$ $1.150$ $0.251689$
## FreqCNT $0.111518$ $0.105692$ $157.457953$ $1.055$ $0.292987$
## QITotal $0.635955$ $0.138134$ $155.814336$ $4.604$ $8.55e-06$ **

---

## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Correlation matrix not shown by default, as p = 17 > 12.
## Use print(x, correlation=TRUE) or
## vcov(x) if you need it
Implementation and Training

Impmod<-lmer(Imp~factor(SettingNew)+factor(PositionNew)+factor(ProfNew)+factor(EnvNew)+ factor(RoleNew) + InterventionLengthCNT + factor(Important) + AchievCNT + EvidenceCNT + FreqCNT + QITotal + (1|Site), data=CSAT5)

summary(Impmod)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [  
## 1merModLmerTest]  
## Formula: Imp ~ factor(SettingNew) + factor(PositionNew) + factor(ProfNew)  
## factor(EnvNew) + factor(RoleNew) + InterventionLengthCNT +  
## factor(Important) + AchievCNT + EvidenceCNT + FreqCNT + QITotal +  
## (1 | Site)  
## Data: CSAT5  
##  
## REML criterion at convergence: 563.5  
##  
## Scaled residuals:  
##     Min      1Q  Median      3Q     Max  
## -3.8317 -0.6558  0.1593  0.5871  2.6847  
##  
## Random effects:  
## Groups   Name        Variance Std.Dev.  
## Site     (Intercept) 0.07095  0.2664  
## Residual             1.3099  1.1445  
## Number of obs: 177, groups: Site, 30  
##  
## Fixed effects:  
## Estimate Std. Error    df t value Pr(>|t|)  
## (Intercept) -1.93747    0.94828 134.7715  -2.043 0.042988 *  
## factor(SettingNew)2 0.27455    0.22389 157.2909    1.226 0.221926  
## factor(PositionNew)2 0.18149    0.23839 159.9782    0.761 0.447578  
## factor(ProfNew)2 0.54926    0.29275 145.0906    1.876 0.062634 .  
## factor(ProfNew)3 0.52711    0.29784 158.1859    1.770 0.078698 .  
## factor(EnvNew)2 0.10993    0.29653  94.3317    0.371 0.711680  
## factor(RoleNew)2 0.41947    0.39242 159.8687    1.069 0.286710  

## Factor (RoleNew) 3
-0.06450 0.25126 159.96053 -0.257 0.797723
## Factor (RoleNew) 4
-0.75318 0.54054 155.04417 -1.393 0.165497
## Factor (RoleNew) 5
-0.01984 0.25016 153.69521 -0.079 0.936877
## Intervention Length CNT
0.04463 0.10482 66.41098 0.426 0.671647
## Factor (Important) 4
-0.20159 0.41481 156.77720 -0.486 0.627670
## Factor (Important) 5
-0.32286 0.33378 151.27735 -0.967 0.334944
## Achieve CNT
0.18734 0.11700 157.07172 1.601 0.111325
## Evidence CNT
0.50289 0.13866 159.24347 3.627 0.000386 ***
## Freq CNT
0.26863 0.13053 152.54000 2.058 0.041292 *
## QI Total
0.70484 0.17061 144.44450 4.131 6.08e-05 ***

### Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

### Correlation matrix not shown by default, as p = 17 > 12.
### Use print(x, correlation=TRUE) or
### vcov(x) if you need it
Monitoring and Evaluation

Monmod<-lmer(Mon~factor(SettingNew)+factor(PositionNew)+factor(ProfNew)+factor(EnvNew)+factor(RoleNew)+InterventionLengthCNT+factor(Important)+AchievCNT+EvidenceCNT+FreqCNT+QITotal+(1|Site), data=CSAT5)
summary(Monmod)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## 1merModLmerTest]
## Formula: Mon ~ factor(SettingNew) + factor(PositionNew) + factor(ProfNew) +
##          factor(EnvNew) + factor(RoleNew) + InterventionLengthCNT +
##          factor(Important) + AchievCNT + EvidenceCNT + FreqCNT + QITotal +
##          (1 | Site)
##    Data: CSAT5
##
## REML criterion at convergence: 585.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9928 -0.5859  0.0654  0.6750  2.0950
##
## Random effects:
##    Groups   Name        Variance Std.Dev.
##    Site     (Intercept) 0.220    0.469
##    Residual             1.533    1.238
## Number of obs: 174, groups:  Site, 30
##
## Fixed effects:
##               Estimate Std. Error    df t value  Pr(>|t|)
## (Intercept)   -1.9934     1.0648 150.6104  -1.872  0.06313 .
## factor(SettingNew)2  0.8489     0.2543 156.2525   3.338  0.00105 **
## factor(PositionNew)2 -0.1092     0.2645 155.6891  -0.413  0.68024
## factor(ProfNew)2   -0.4053     0.3322 156.5921  -1.220  0.22427
## factor(ProfNew)3   -0.1026     0.3329 155.8281  -0.308  0.75842
## factor(EnvNew)2    -0.1431     0.3358 154.8114  -0.426  0.67073
## factor(RoleNew)2    0.5089     0.4381 154.0537   1.162  0.24719
## factor(RoleNew)3
-0.1389 0.2787 154.5806 -0.499 0.61875
## factor(RoleNew)4
-0.7919 0.6003 156.9661 -1.319 0.18905
## factor(RoleNew)5
-0.0246 0.2809 156.9090 -0.088 0.93033
## InterventionLengthCNT 0.1222 0.1218 113.5612 1.003 0.31818
## factor(Important)4
-0.2701 0.4514 150.8268 -0.598 0.55045
## factor(Important)5
-0.4155 0.3638 147.9671 -1.142 0.25529
## AchievCNT 0.1697 0.1298 156.9295 1.307 0.19322
## EvidenceCNT 0.4684 0.1566 155.8464 2.990 0.00324 **
## FreqCNT 0.1894 0.1467 154.5720 1.291 0.19863
## QITotal 0.9288 0.1910 155.9212 4.862 2.81e-06 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation matrix not shown by default, as p = 17 > 12.
## Use print(x, correlation=TRUE) or
## vcov(x) if you need it
Outcomes and Effectiveness

\[
\text{Outmod} \leftarrow \text{lmer(Out \sim \text{factor(SettingNew)} + \text{factor(PositionNew)} + \text{factor(ProfNew)} + \text{factor(EnvNew)} + \text{factor(RoleNew)} + \text{InterventionLengthCNT} + \text{factor(Important)} + \text{AchievCNT} + \text{EvidenceCNT} + \text{FreqCNT} + QITotal + (1 | Site), data=CSAT5)}
\]

\[
\text{summary(Outmod)}
\]

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [\text{lmerModLmerTest}]

## Formula: Out \sim \text{factor(SettingNew)} + \text{factor(PositionNew)} + \text{factor(ProfNew)} + \text{factor(EnvNew)} + \text{factor(RoleNew)} + \text{InterventionLengthCNT} + \text{factor(Important)} + \text{AchievCNT} + \text{EvidenceCNT} + \text{FreqCNT} + QITotal + (1 | Site)

## Data: CSAT5

## REML criterion at convergence: 451.6

## Scaled residuals:

<table>
<thead>
<tr>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.84806</td>
<td>-0.61385</td>
<td>0.03218</td>
<td>0.62184</td>
<td>2.54964</td>
</tr>
</tbody>
</table>

## Random effects:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>Std.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>(Intercept)</td>
<td>0.01185</td>
<td>0.1088</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>0.73733</td>
<td>0.8587</td>
</tr>
</tbody>
</table>

Number of obs: 171, groups: Site, 30

## Fixed effects:

|                        | Estimate | Std. Error | df  | t value | Pr(>|t|) |
|------------------------|----------|------------|-----|---------|----------|
| (Intercept)            | 1.48025  | 0.70146    | 132.48411 | 2.110 | 0.03672 * |
| factor(SettingNew)2   | -0.03942 | 0.16943    | 150.83138 | -0.233 | 0.81635 |
| factor(PositionNew)2   | 0.21282  | 0.18051    | 153.71324 | 1.179 | 0.24023 |
| factor(ProfNew)2       | 0.23956  | 0.22070    | 130.90010 | 1.085 | 0.27972 |
| factor(EnvNew)2        | 0.14199  | 0.21552    | 52.49839  | 0.659 | 0.51288 |
| factor(RoleNew)2       | 0.39186  | 0.28596    | 153.96160 | 1.370 | 0.17257 |
## factor(RoleNew)3
-0.02671  0.19020  153.99694  -0.140  0.88851
## factor(RoleNew)4
-0.28378  0.39947  146.40773  -0.710  0.47859
## factor(RoleNew)5
0.15395  0.18802  145.40065  0.819  0.41426
## InterventionLengthCNT
-0.07821  0.07951  67.21187  -0.984  0.32881
## factor(Important)4
-0.02648  0.31155  153.23220  -0.085  0.93239
## factor(Important)5
0.23815  0.24879  152.34045  0.957  0.33997
## AchievCNT
0.02799  0.08697  149.70695  0.322  0.74804
## EvidenceCNT
0.49169  0.10847  152.07145  4.533  1.17e-05 ***
## FreqCNT
0.10451  0.09634  144.79566  1.085  0.27984
## QITotal
0.42695  0.12722  131.21126  3.356  0.00104 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Appendix D: Interview Guide

Experience of Sustainability

In a few sentences, please tell me about your role in the hospital.

1. After a new practice is implemented, what is your role in maintaining it?
   a. Do you feel like your role is important?
   b. Do you think about it on a day-to-day basis?

I’d like for you to think about a specific practice change you’ve participated in the implementation of within the clinical setting.

2. Is the practice or program still around today?
   a. If not, say more about why the practice did not ‘survive’
   b. If yes, what do you think has been the main reasons that it still exists

3. Are there any key stakeholders that the program relies on? What roles do they have?
   a. If not mentioned, ask about the role of the frontline clinician

4. Are you concerned that this program will cease to exist at your hospital?
   a. What do you think the biggest threats are to this program continuing?
   b. If you could do anything to ensure this program continued, what would that be?

Now, I’d like to think more broadly about other practice changes (like surgical prophylaxis, or reduced blood culture ordering, etc.)

5. When these types of systematic changes are implemented in your unit/program, do you plan for how they will continue over time?
   a. In what ways?

Constructs of Clinical Sustainability
1. What are the most important things at your hospital that are important to make it feasible for practices to continue over time?
   a. Possibly have follow-ups based on apparent barriers/facilitators.
   b. [Refer to domains and prompt around domains that are/are not mentioned]
      i. Stakeholders - willing partners in the work
      ii. Engaged staff
      iii. Monitoring/evaluation
      iv. Implementation/training
      v. Outcomes/effectiveness
      vi. Workflow integration – informatics support
      vii. Organizational readiness
   c. How do you think that this being integrated into the workflow [or not] changes how it is delivered?
   d. Do you think about how money affects how programs and practices continue?
   e. Do you feel like clinicians see the health outcomes of this practice in patients?
      i. How does this influence practice delivery?

2. Does it feel like there is anything that really influences the sustainability of your program that we have not addressed?
# Appendix E: Qualitative Codebook

<table>
<thead>
<tr>
<th>Framework</th>
<th>Code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSAT</td>
<td>Stakeholders</td>
<td>Having external support and engagement for the practice; discussion of the stakeholders involved</td>
</tr>
<tr>
<td>CSAT</td>
<td>Engaged Staff</td>
<td>Having supportive frontline staff and management within the organization; discussion of any of the staff and multi-professional partnerships involved.</td>
</tr>
<tr>
<td>CSAT</td>
<td>Monitoring/ Evaluation</td>
<td>Assessing the practice to inform planning and document results; descriptions of the efforts that they took (successful or not) to monitor and evaluate the practice</td>
</tr>
<tr>
<td>CSAT</td>
<td>Implementation/ training</td>
<td>Any strategies that were utilized with the program or practice; importance of processes that guide the direction, goals and strategies of the practice</td>
</tr>
<tr>
<td>CSAT</td>
<td>Outcomes/ effectiveness</td>
<td>Statements about the outcomes, clinical impact, or efficacy of the intervention/practice</td>
</tr>
<tr>
<td>CSAT</td>
<td>Workflow integration</td>
<td>Description of how the practice fits into existing practices and technologies</td>
</tr>
<tr>
<td>CSAT</td>
<td>Organizational readiness</td>
<td>Having the internal support and resources needed to effectively manage the practice; any discussion of the time, space, staff, operational aspects of the practice</td>
</tr>
<tr>
<td>CSAT</td>
<td>Other</td>
<td>Open for any other relevant ideas about sustainability that did not fit into other codes.</td>
</tr>
<tr>
<td>EPIS</td>
<td>Not sustained</td>
<td>Description of a program, practice, or initiative that did not continue.</td>
</tr>
<tr>
<td>EPIS</td>
<td>Sustained</td>
<td>Description of a program, practice, or initiative that continued over time.</td>
</tr>
<tr>
<td>EPIS</td>
<td>Planning</td>
<td>Any efforts or organize around the implementation or sustainment, thinking ahead to develop strategies.</td>
</tr>
<tr>
<td>EPIS</td>
<td>Individual duties and characteristics</td>
<td>The roles and responsibilities of individuals, any specific individual tasks that they are responsible for.</td>
</tr>
<tr>
<td>EPIS</td>
<td>Barrier</td>
<td>Often used in conjunction with organization readiness, this described when people discussed hindrances to sustaining practices that they perceived to be a function of the setting or unit</td>
</tr>
<tr>
<td>EPIS</td>
<td>Enabler</td>
<td>Often used in conjunction with organization readiness, this described when people discussed facilitators to sustaining practices that they perceived to be a function of the setting or unit</td>
</tr>
<tr>
<td>EPIS</td>
<td>Money/Financial Support</td>
<td>Description about how finances do/do not influence implementation or sustainability; any mention of money</td>
</tr>
<tr>
<td>EPIS</td>
<td>Bridging Factors</td>
<td>The factors that go between settings/contexts; anything that connects the settings or influences across an organizational boundary</td>
</tr>
<tr>
<td>EPIS</td>
<td>Innovation Factors</td>
<td>Mentions of how the intervention itself, or its characteristics, are relevant to implementation and sustainability</td>
</tr>
</tbody>
</table>
Appendix F: Social Network Survey

This survey was created by Douglas Luke, Jason Newland, Bobbi Carothers, and Sara Malone.

Q1 Instructions
Thank you for taking the time to complete this survey. If you're taking the survey on a mobile device, it will perform best if you hold it in the "landscape" orientation. If you need to save your work and come back to it later, clicking the "Save and Continue" button on the bottom of the page will save your work, clicking the "Back" button will return you to that page, and then you are free to exit your browser. To return to the survey, just click on the link in the email that first directed you here. Once you have submitted your responses, you will no longer be able to come back to change them. Please use the buttons at the bottom of the survey to navigate instead of the back and forward buttons on your browser to ensure that your information is properly recorded. If you have any questions or need help completing the assessment, please contact Sara Malone at sara.malone@wustl.edu. I have read the consent document and agree to participate in this survey.

I agree (1)  I do not agree (2)

Q2 Welcome
All of the questions in this survey refer to who in your hospital you communicate with and/or consult regarding surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration).

Q3 Contact - Antimicrobial Stewardship Team
Please indicate which of the following people you know and if you have had direct contact (e.g., meetings, phone calls, emails, faxes, or letters) with them within the last 12 months SPECIFICALLY related to surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration). (Do not count listservs or mass emails).

<table>
<thead>
<tr>
<th></th>
<th>I don’t know this person (1)</th>
<th>I know this person but have no contact with them (2)</th>
<th>I have had contact with this person within the last 12 months (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name 1 (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name 2 (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name 3 (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q4 General Surgery
Do you know anyone from General Surgery?
Yes (1)
No (2)

Display This Question:
If do you know anyone from General Surgery? = Yes

Q5 Contact
Please indicate which of the following people you know and if you have had direct contact (e.g., meetings, phone calls, emails, faxes, or letters) with them within the last 12 months SPECIFICALLY related to surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration). (Do not count listservs or mass emails).

<table>
<thead>
<tr>
<th>I don’t know this person (1)</th>
<th>I know this person but have no contact with them (2)</th>
<th>I have had contact with this person within the last 12 months (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name 1 (1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q6 Neurosurgery
Do you know anyone from Neurosurgery?
Yes (1)
No (2)

Display This Question:
If Do you know anyone from Neurosurgery? = Yes

Q7 Contact
Please indicate which of the following people you know and if you have had direct contact (e.g., meetings, phone calls, emails, faxes, or letters) with them within the last 12 months
specifically related to surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration). (Do not count listservs or mass emails).

<table>
<thead>
<tr>
<th>I don’t know this person (1)</th>
<th>I know this person but have no contact with them (2)</th>
<th>I have had contact with this person within the last 12 months (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name 1 (1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q8 Orthopedic Surgery
Do you know anyone from Orthopedic Surgery?
Yes (1)
No (2)

Display This Question:
If Do you know anyone from Orthopedic Surgery? = Yes

Q9 Contact
Please indicate which of the following people you know and if you have had direct contact (e.g., meetings, phone calls, emails, faxes, or letters) with them within the last 12 months specifically related to surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration). (Do not count listservs or mass emails).

<table>
<thead>
<tr>
<th>I don’t know this person (1)</th>
<th>I know this person but have no contact with them (2)</th>
<th>I have had contact with this person within the last 12 months (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name 1 (1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q10 Otolaryngology
Do you know anyone from Otolaryngology?
Yes (1)
No (2)

Display This Question:
If Do you know anyone from Otolaryngology? = Yes

Q11 Contact
Please indicate which of the following people you know and if you have had direct contact (e.g., meetings, phone calls, emails, faxes, or letters) with them within the last 12 months SPECIFICALLY related to surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration). (Do not count listservs or mass emails).

<table>
<thead>
<tr>
<th></th>
<th>I don’t know this person (1)</th>
<th>I know this person but have no contact with them (2)</th>
<th>I have had contact with this person within the last 12 months (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name 1 (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q12 Plastic Surgery
Do you know anyone from Plastic Surgery?
Yes (1)
No (2)

Display This Question:
If Do you know anyone from Plastic Surgery? = Yes

Q13 Contact
Please indicate which of the following people you know and if you have had direct contact (e.g., meetings, phone calls, emails, faxes, or letters) with them within the last 12 months
**SPECIFICALLY related** to surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration). (Do not count listservs or mass emails).

<table>
<thead>
<tr>
<th>Name 1 (1)</th>
<th>I don’t know this person (1)</th>
<th>I know this person but have no contact with them (2)</th>
<th>I have had contact with this person within the last 12 months (3)</th>
</tr>
</thead>
</table>

Q14 Urology
Do you know anyone from Urology?
Yes (1)
No (2)

*Display This Question:*
If Do you know anyone from Urology? = Yes

Q15 Contact
Please indicate which of the following people you know and if you have had direct contact (e.g., meetings, phone calls, emails, faxes, or letters) with them within the last 12 months **SPECIFICALLY related** to surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration). (Do not count listservs or mass emails).

<table>
<thead>
<tr>
<th>Name 1 (1)</th>
<th>I don’t know this person (1)</th>
<th>I know this person but have no contact with them (2)</th>
<th>I have had contact with this person within the last 12 months (3)</th>
</tr>
</thead>
</table>

Q16 Collaboration
For the individuals you indicated having contact with, please check any of the activities **SPECIFICALLY related** to antibiotic surgical prophylaxis (e.g., antibiotic selection, dose, duration) you have collaborated with them on in the last 12 months. [Check all that apply]
<table>
<thead>
<tr>
<th>Clinical Care (1)</th>
<th>Committee Work (2)</th>
<th>Care Standardization (e.g., guidelines) (3)</th>
<th>Research (4)</th>
<th>Quality Improvement Initiatives (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name 1 (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q17 Information Seeking
Please indicate the likelihood that you would approach each of the following individuals if you had a question about surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration).

<table>
<thead>
<tr>
<th>Not at all (1)</th>
<th>Somewhat Unlikely (2)</th>
<th>Neither Likely nor Unlikely (3)</th>
<th>Somewhat Likely (4)</th>
<th>Very Likely (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name 1 (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q18 Decision Making
Please rate your confidence for the following statements.

<table>
<thead>
<tr>
<th>Not at all Confident (1)</th>
<th>Not very Confident (2)</th>
<th>Neutral (3)</th>
<th>Somewhat Confident (4)</th>
<th>Very Confident (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel confident that I can get all the information I need regarding surgical antibiotic prophylaxis (e.g., antibiotic selection, dose, duration). (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| I feel confident that I can make the most appropriate choices regarding antibiotic prophylaxis in clean and clean-contaminated surgeries. (2) | | | | |

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Appendix G: Aim 3 Full Network Visualizations

Site 1 Collaboration Networks
Site 2 Collaboration Networks

Clinical

Research

Quality Improvement

Standardized Care

Committee

Any Collaboration
Site 3 Collaboration Networks

Clinical

Research

Quality Improvement

Standardized Care

Committee

Any Collaboration
Site 4 Collaboration Networks
Site 5 Collaboration Networks

Clinical

Research

Quality Improvement

Standardized Care

Committee

Any Collaboration
Site 6 Collaboration Networks

Clinical

Research

Quality Improvement

Standardized Care

Committee

Any Collaboration
Site 7 Collaboration Networks

Clinical

Research

Quality Improvement

Standardized Care

Committee

Any Collaboration
Site 8 Collaboration Networks

Clinical

Research

Quality Improvement

Standardized Care

Committee

Any Collaboration
Site 9 Collaboration Networks

Clinical

Research

Quality Improvement

Standardized Care

Committee

Any Collaboration
Other Site Information Seeking Networks

Site 5

Site 2

Site 9

Section
- Antimicrobial Stewardship Team
- General Surgery
- Neurosurgery
- Orthopedic Surgery
- Otolaryngology
- Plastic Surgery
- Urology