EVALUATING THE TEAM AND IMPLEMENTATION FACTORS ASSOCIATED WITH HOSPITAL-BASED COMPREHENSIVE UNIT-BASED SAFETY PROGRAM (CUSP) TEAM EFFECTIVENESS

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A dissertation submitted to Johns Hopkins University in conformity with the requirements for the degree of Doctorate in Public Health

Baltimore, MD
February 2017
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Abstract

Problem Statement: The Comprehensive Unit-based Safety Program (CUSP) has been successfully implemented in thousands of clinical areas across the United States and around the world and has demonstrated improvements in clinical outcomes, operational outcomes and safety culture. Despite its overwhelming success, some CUSP teams have been more successful than others and the factors associated with success are not well understood.

Purpose: The purpose of this dissertation is to examine the team and implementation factors associated with CUSP team effectiveness using a transdisciplinary framework combining team theory and implementation science.

Methods: This study used prospectively collected administrative data from CUSP teams from a large, multi-hospital health system. Multivariate linear regression, multivariate logistic regression and multivariate negative binomial regression modeling were used to examine the associations between CUSP team structures, processes, proximal outcomes (total CUSP projects completed) and the distal outcome of unit-level patient safety climate scores.

Results: A total of 88 of 106 CUSP teams had sufficient data to include in this analysis. Compared to teams with champions that received no safety training, teams whose champions received both CUSP basic training and Patient Safety Certificate training had 7.76 greater odds ($p=0.07$) of having high provider attendance versus low provider attendance. There were significant differences ($p=0.02$) among unit types (ICU, non-
ICU, other) in the odds of having high provider attendance versus low provider attendance. For CUSP teams that met regularly, there was an 8.33-fold increase ($p=0.009$) in the total number improvement projects completed for every one percentage point increase in the percentage of meetings held. There was a significant association between the age of the teams and total team projects completed with more projects being completed as age increased (Incidence rate ratio (IRR) = 1.003, 95% confidence interval (CI): 1.000, 1.007, $p=0.03$). Contrary to the hypotheses, there was significant less improvement projects completed when provider attendance was highest (IRR = 0.59, 95% CI: 0.41, 0.84, $p=0.009$). There was no association detected between total projects completed (proximal outcome) and unit-level safety climate domain scores (distal outcome).

**Conclusion:** There are several key team and implementation factors associated with CUSP team effectiveness. Unit type is associated with provider attendance, differences exist between hospitals with regard to regular meeting being held, regular meetings and the age of the team were associated with total projects completed while regular provider attendance was associated with less projects completed. More research is needed to confirm these findings and to identify the proximal team outcome(s) that are associated with the distal outcome of unit-level patient safety climate scores.
Chapter 1: Introduction

Patient Safety in Healthcare

Despite enormous pressure from policy makers to patients in the seventeen years since to Err is Human was published, there are few instances of success in reducing preventable harm in healthcare.1-4 In order to achieve and sustain improvements that reduce preventable harm, healthcare must learn to become highly reliable.5-7 One core component essential to reducing preventable harm and becoming highly reliable is to create a culture of safety.1,7-10 The comprehensive unit-based safety program (CUSP), teamwork and communication training, and executive walk rounds are three of the interventions that are associated with improvements in patient safety culture.8,9 Unfortunately, few studies describe the critical aspects associated with success.9,11,12

Overview of CUSP

The Comprehensive Unit-based Safety Program (CUSP), developed at Johns Hopkins, is a five step program that improves specific safety outcomes and safety culture.13-18 The five steps of CUSP include17:

1. Training staff in the science of safety
2. Identifying defects
3. Partnering with a senior executive
4. Learning from defects
5. Implementing improvement tools
CUSP’s success in reducing central line-associated blood stream infections (CLABSI) in the State of Michigan from 2003-2005, the Agency for Healthcare Research and Quality funded the *On the CUSP: STOP BSI* program in which CUSP was implemented in 1,071 ICU’s in 44 states across the United States and resulted in an 43% reduction of CLABSI’s.2,13 Subsequently, CUSP, in combination with clinical interventions, reduced the risk of ventilator-associated pneumonia (VAP) and surgical site infections (SSI).13,18-20

In addition to outcomes such as CLABSI, SSI and VAP noted above, the implementation of CUSPsuggest is the program is associated with improvements in safety climate scores as measured by the Safety Attitudes Questionnaire (SAQ).21 In turn, improvements in safety climate are associated with downstream safety outcomes such as improvements in nurse turnover.17,22

Although CUSP rose to prominence through the success of the national program to reduce CLABSI, it began as a program to improve patient safety generally, and implementation of CUSP has continued at Johns Hopkins since its inception in 2001.2,13,21,23 Today there are 158 CUSP teams throughout Johns Hopkins Medicine, a large health system that includes 2 large tertiary-care academic medical centers, 1 large tertiary-care academic pediatric medical center, 3 community hospitals, a large 35-site ambulatory community practice and a home care company.24
While CUSP can improve safety outcomes and facilitate quality improvement, some CUSP teams are more successful than others. The factors associated with their success are currently not well understood. **The purpose of this dissertation is to examine the team and implementation factors associated with CUSP effectiveness using a transdisciplinary framework combining team theory and implementation science.** Specifically, this study aims to examine the CUSP structures, processes, and proximal outcomes associated with the distal outcome of unit-level patient safety climate.

CUSP provides unit-level infrastructure for improvements in safety and quality by engaging the spectrum of stakeholders from front-line staff to institution executives. This begins with the assembly of an active and engaged team that acquires safety training, continued focus on teamwork, identification of problems and interventions to address these problems. Using the specific steps of CUSP as a guideline, experts at Johns Hopkins, including those who designed the program initially and those who continue to oversee its successful implementation locally, nationally, and internationally, defined a “Scorecard” to evaluate the progress and performance of CUSP teams.

**Evaluating CUSP Team Processes and Outcomes: The CUSP Scorecard**

To develop the CUSP Scorecard a group of five CUSP experts and measurement experts were brought together in 2012 to develop a set of measures that could potentially identify the team and implementation factors associated with success. These measures
needed to be specific to the CUSP program and feasible to collect by an organization regardless of the number of CUSP teams. Eight measures were ultimately selected that were believed to achieve both of these goals. The CUSP Scorecard was pilot tested across 14 CUSP teams in one department in 2013, feedback was obtained and adjustments were made to the Scorecard. The final CUSP Scorecard was then implemented across Johns Hopkins Medicine starting in July, 2014 (Appendix A). The development of the CUSP scorecard underscored the need to understand the team and implementation factors associated with CUSP team effectiveness and provided a mechanism to start to investigate some of these important questions.

Theoretical Framework

Understanding the factors associated with CUSP team success is rooted in multiple fields of science. First, team science from the perspective of organizational psychology and organizational behavior offers important insights into the characteristics of highly functional teams. As healthcare becomes increasingly complex and reliant on individuals working within teams to deliver care an understanding of the drivers of team performance and effectiveness are also critical. Next, the science of project management offers critical knowledge regarding the relationship between project teams and project performance. Finally, the classic Donabedian model of structure, process, and outcomes to evaluate quality in medical care, from implementation and improvement science, provides critical insights into factors associated with health outcomes. Donabedian’s model emphasized that health care structures were driving
forces for care processes that ultimately lead to health outcomes. By drawing on the knowledge across all three fields I propose a theoretical framework designed to articulate some of the team and implementation factors associated with CUSP effectiveness (Figure 1). Teams theory differentiates intra vs. inter team processing in examining CUSP team processes. Intra-team structures such as team knowledge, team leader knowledge, and the amount of dedicated time given to the team leader are critical drivers for teams. Intra-team processes, including communication processes and the functional diversity of the team, are important to achieve the proximal CUSP team outcomes and may be effected by how long the team has been working together. In this framework, functional diversity of the team is included as an intra-team process rather than an intra-team structure because the degree of functional diversity within the team (as measured by attendance) represents a proxy indicator of interdisciplinary discussion and collective problem solving during a team meeting. The primary goal, or proximal outcome, of CUSP teams has been to learn from defects. Learning from defects, as defined in the CUSP program, represents the impactful products (projects) of the CUSP team processes. These can include projects associated with either rate-based preventable harm or non-rate based preventable harm. Together these projects are called total CUSP team projects. Project management science differentiates proximal team outcomes from distal team outcomes. Distal team outcomes, like safety culture, are the value the output creates for the organization. Proximal outcomes are more closely related contextually to their antecedents and correlations should be stronger than for more distal outcomes. Finally, organizational
characteristics broadly impact the team, projects and outcomes.\textsuperscript{25,27} This framework provides theoretical grounding for the conceptual model of CUSP team effectiveness and the specific aims and hypotheses to be tested.

\textit{Figure 1: Theoretical CUSP Framework Adapted from Donabedian and Team Science}

\textit{Conceptual Model of CUSP Team Effectiveness}

We applied the theoretical framework in the specific CUSP context to develop a conceptual model of CUSP team effectiveness (Figure 2). \textit{Intra-team structures} include both team characteristics, such as the teams’ knowledge of the science of safety, and individual characteristics, such as the CUSP champions training in safety and amount of time that he/she has to dedicate to the CUSP team and its projects. \textit{Intra-team processes} include how often the CUSP team is meeting and the diversity of those attending the meetings. CUSP teams that have strong \textit{intra-team structures} and strong \textit{intra-team processes} will lead to strong \textit{intra-team proximal outcomes} and ultimately, strong \textit{distal team outcomes}. For example, CUSP teams that cancel meetings will have fewer opportunities to plan and execute CUSP team projects and CUSP teams with less
functional diversity will execute less projects due to lack of leadership or physician support. Finally, the distal team outcome of safety culture was measured using the safety climate domain of the Safety Attitudes Questionnaire.²²

Figure 2: Conceptual Model of CUSP Team Effectiveness

Study Aims and Hypotheses

Using the CUSP Scorecard data, we investigated the association between the elements of CUSP and safety climate by examining the following specific aims.

Aim 1: Examine the CUSP team structures and processes that are associated with proximal CUSP team outcomes (total CUSP team projects).

Hypothesis 1: Teams reporting more (a) protected time and (b) training for the team CUSP Champion, and (c) SOS training for staff will report greater provider attendance than those reporting less protected time and training for their CUSP Champion and less training of their staff.
**Hypothesis 2:** Teams reporting more (a) protected time for the team CUSP Champion, (b) training for CUSP champion, and (c) SOS training for staff will also report greater executive attendance than those reporting less protected time and training for their CUSP Champion and less training of their staff.

**Hypothesis 3:** Teams reporting more (a) protected time for the team CUSP Champion and (b) training for the champion and (c) SOS training for staff will also report more meetings held than those reporting less protected time and training for their CUSP Champion and less training of their staff.

**Hypothesis 4:** Teams reporting greater (a) provider and (b) executive attendance and (c) meetings held will also report higher number of CUSP team projects than those reporting less attendance and meetings held.

**Aim 2:** Examine the association between proximal CUSP team outcomes (total CUSP team projects completed) and unit-level safety climate, a distal CUSP team outcome.

**Hypothesis 1:** Teams reporting more total CUSP team projects will also report higher unit-level safety climate scores than those reporting fewer total team projects.

**Aim 3:** Examine the association between the CUSP processes and unit-level safety climate.

**Hypothesis 1:** The relationship between CUSP processes (a) provider and (b) executive attendance and (c) meetings held rates and unit-level safety climate is partially mediated by the proximal team outcomes.
<table>
<thead>
<tr>
<th>Aim/ Theory</th>
<th>Dependent Variables (Type)</th>
<th>Independent Variables (Type)</th>
<th>Covariates/ potential confounders Variables (Type)</th>
</tr>
</thead>
</table>
| A1 H1      | <80% of meetings with provider in attendance, ≥80% of meetings with provider in attendance (dichotomous) | • % of staff with SOS training (continuous)  
• CUSP champion training (ordinal)  
• Protected time for champion (continuous) | • Affiliate ID (nominal)  
• Unit type (nominal) |
| A1 H2      | % executive attendance (continuous) | • % of staff with SOS training (continuous)  
• CUSP champion training (ordinal)  
• Protected time for champion (continuous) | • Affiliate ID (nominal)  
• Unit type (nominal) |
| A1 H3      | <80% of meetings held, ≥80% of meetings held (dichotomous) | • % of staff with SOS training (continuous)  
• CUSP champion training (ordinal)  
• Protected time for champion (continuous) | • Affiliate ID (nominal)  
• Unit type (nominal) |
| A1 H4      | # of total CUSP team projects (count) | • % of CUSP meetings held (continuous), spline knot at 80%  
• % provider attendance (continuous)  
• % executive attendance (continuous) | • % of staff with SOS training (continuous)  
• CUSP champion training (ordinal)  
• Protected time for champion (continuous)  
• Affiliate ID (nominal)  
• Unit type (nominal)  
• Age of CUSP team (continuous) |
| A2 H1      | Safety climate domain score (continuous) | • # of total CUSP team projects (count) | • % of CUSP team meetings held (continuous)  
• % provider attendance (continuous)  
• % executive attendance (continuous)  
• Affiliate ID (nominal)  
• Unit type (nominal) |
| A3 H1      | Safety climate domain score (continuous) | • % of CUSP meetings held (continuous)  
• % executive attendance (continuous)  
• % provider attendance (continuous) | • Affiliate ID (nominal)  
• Unit type (nominal)  
• # of total CUSP team projects (count) |

*Mediator
Significance

There is a growing demand from patients to policy makers that healthcare organizations must deliver the best quality care, every single time, at the lowest possible cost.\textsuperscript{5,28} Healthcare organizations are far from achieving this goal. In order to achieve these goals healthcare organizations must work toward becoming highly reliable, in other words, mindful. Organizations that engage in mindful organizing commit to safety at all levels, which creates a “culture of safety”.\textsuperscript{5,7} CUSP is one intervention in healthcare that promotes a culture of safety.\textsuperscript{8} Despite spreading CUSP across thousands of teams in the United States and around the world it is not yet known what team and implementation factors are associated with CUSP success. This leaves organization leaders in the dark regarding the critical elements that must be in place to truly spread CUSP across their organization in order to create organizational mindfulness. As the CUSP program continues to proliferate across the United States and beyond, there is a growing need to understand which CUSP team structures and processes are associated with proximal CUSP team outcomes. And to understand what, if any, associations exist between these and distant CUSP team outcomes like improvements in unit-level safety climate domain scores. This will allow for organizational leaders to appropriately invest in the CUSP program and will allow teams to drive performance on the critically important steps associated with improving a culture of safety.

This dissertation begins to answer some of these important questions. For example, are teams more successful when specific organizational structures are in place, for instance,
when a CUSP champion has dedicated time for improvement related work? If so, how much dedicated time is necessary? Providing dedicated time to do this work may be an expensive but necessary step to achieving CUSP outcomes and ultimately achieving organizational mindfulness.

Chapter 2: Literature Review

Mindful Organizing and High Reliability

The hypotheses examined in this study draw together several theoretical schools of thought, including (1) high reliability theory, (2) implementation science and (3) team science from the perspectives of organizational psychology and project management science. Each is briefly summarized and synthesized in order to describe the theoretical landscape that serves as a foundation for the specific hypotheses examined in this study. Findings from previous studies of CUSP and safety climate measurement are also examined and summarized.

Since the 1999 Institute of Medicine report, To Err is Human, healthcare has sought to eliminate preventable harm and create a learning culture in which errors are investigated and responses to mistakes are just. Arguably few organizations in healthcare have achieved this level of quality so healthcare has looked to other industries to identify the very characteristics that help them achieve high reliability. Previous research by Vogus and Sutcliffe identified five characteristics that all members
of an organization must commit to in order to become highly reliable. These include sensitivity to operations, preoccupation with failure, deference to expertise, resilience, and a reluctance to simplify. Collectively these are referred to as organizational mindfulness. In order to approach organizational mindfulness, organizations must start on a path to engage everyone, especially frontline staff in mindful organizing. Mindful organizing “represents a dynamic process comprising specific ongoing actions rather than enduring organizational characteristic (p.724).” It relies on continuous real-time communication and interactions, results from bottom-up processes, and engages the front line in thinking and action within an organization.

Highly reliable organizations demonstrate a preoccupation with failure. People within resilient organizations are constantly looking for small cues that systems are not acting as they should, are resistant to normalizing unexpected findings, are wary even when there are signs of success, and are able to maintain a “spirit of contradiction” or doubt as opposed to a “spirit of accord” (p.52). Highly reliable organizations demonstrate a reluctance to simplify. People within mindful organizations are reluctant to simplify because doing so hides signals and details which leads to unreliable performance. These threats to performance can have subtle, but important, distinctions and oversimplifying them may mean the difference between early and late detection. Highly reliable organizations demonstrate a sensitivity to operations. People within these organizations are acutely aware that early threats to organizational performance are often seen in the daily operations. As a result, early signal of deviations of
performance within a system must be reported and acted upon. Failures to detect these early warnings can be a result of ignorance, casualness and distractions. In order to avoid these, Todd LA Porte (p. 224) describes the need for operators to engage in “the state of cognitive integration and collective mind that allows the integration of tightly coupled interactive complexity as a dynamic operational process”. Highly reliable organizations demonstrate resilience. They are not error-free but they are also not disabled when errors do occur. People within resilient organizations recognize errors quickly and contain them before causing harm. To achieve organizational resilience, the organization must learn from error and implement learning swiftly. Highly reliable organizations demonstrate a deference to those with the most expertise. When a situation arises, people within these organizations must have an understanding of the limits of their own knowledge and experience and have mechanisms in place to quickly identify the individuals who do. These mechanisms are indifferent to hierarchy and rank. In summary, healthcare organizations must work toward becoming highly reliable. In order to move the organization in this direction all members of the organization must commit to practicing these five characteristics. Collectively these are what moves an organizational into mindfulness. Mindful organizations commit to safety at all levels, which creates a “culture of safety.”

**Patient Safety Culture and Patient Safety Climate**

A hallmark of highly reliable organizations is an organizational commitment to safety throughout all levels of the organization. It is through this commitment that the
organization creates a culture of safety.\textsuperscript{5} The term safety culture was first used in the investigational report following the Chernobyl disaster and stated, “safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance” (p.89).\textsuperscript{35,36} In 2004, the Agency for Healthcare Research and Quality (AHRQ) funded the development of a hospital survey to measure safety attitudes called the Hospital Survey of Patient Safety Culture.\textsuperscript{37} AHRQ adopted the following definition of safety culture stating (p.1):

“The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization’s health and safety management. Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures”.\textsuperscript{37}

Patient safety culture and safety climate are often used interchangeably in healthcare practice. While patient safety culture is described above, patient safety climate refers to the shared perceptions about the norms, policies, and procedures related to patient safety.\textsuperscript{8} Specifically, climate is measured using a questionnaire and provides information from a moment in time from clinician’s and staff of the observable attributes of safety culture.\textsuperscript{8}

\textit{Evaluating Patient Safety Climate}

The airline industry began measuring pilot attitudes about safety and interpersonal interactions through surveys including the Flight Management Attitude Questionnaire
(FMAQ) and Cockpit Management Attitudes Questionnaire (CMAQ).\textsuperscript{38,39} This early work found that these attitudes were responsive to training interventions and could predict performance.\textsuperscript{40} In 2006, Sexton and colleagues, developed the Safety Attitudes Questionnaire (SAQ), a healthcare-specific survey to measure the attitudes of healthcare workers toward patient safety.\textsuperscript{22} Since safety climate is a more readily measurable aspect of safety culture, Sexton’s SAQ survey measured 6 domains of safety including safety climate, teamwork climate, job satisfaction, perceptions of management, stress recognition and working conditions.\textsuperscript{22} The SAQ is a valid and psychometrically sound instrument for assessing these 6 safety-related domains.\textsuperscript{22} Over time it has been found to be sensitive to interventions, including CUSP.\textsuperscript{2,21,41,42} After recognizing the potential association between culture and outcomes, the Joint Commission began requiring that all hospitals regularly evaluate their culture of patient safety beginning in 2007.\textsuperscript{43,44}

\textit{Implementation Science and The Comprehensive Unit-based Safety Program}

The comprehensive unit-based safety program started in 2001 in two surgical intensive care units (ICU), the Weinberg intensive care unit (WICU) and the surgical intensive care unit (SICU), at Johns Hopkins Hospital.\textsuperscript{21} CUSP began as an eight step program to engage and empower staff to identify and eliminate hazards and ultimately improve the climate of safety.\textsuperscript{21} This study was a quasi-experimental design with one unit receiving the intervention, CUSP, immediately and the other unit serving as a control for 6 months prior to receiving the intervention. Safety climate was measured in both units before
and six months after the implementation of CUSP. A medical version of aviation’s Safety Climate Scale was used to assess culture. Compared to the pre-intervention survey, the WICU and SICU achieved statistically significant improvements (p<0.05) in the post-intervention period with regard to three statements: 1) The physician and nurse leaders in my area listen to me and care about my concerns, 42% relative improvement in the WICU and 121% relative improvements in the SICU, 2) My suggestions about safety would be acted upon if I expressed them to management, 53% relative improvement in the WICU and 51% relative improvement in the SICU, 3) I am aware that patient safety has become a major area for improvement in my institution, 41% relative improvement in the WICU and 46% relative improvement in the SICU. Interestingly, the WICU also saw statistically significant improvements in the following 5 items: 1) I am encouraged by my supervisors and coworkers to report any unsafe conditions I observe, 2) I know the proper channels to report my safety concerns, 3) I am satisfied with availability of clinical leadership, 4) Leadership is driving us to be a safety-centered institution, and 5) I believe that most adverse events occur as a result of multiple system failures, and are not attributable to one individual’s actions. Overall, the SICU’s percent of staff reporting a positive safety climate improved from 34.6% to 52.2% and the WICU’s improved from 40% to 67.7%. In addition, both ICU’s saw statistically significant reductions (p<0.05) in their length of stay from 2.2 to 1.1 in the WICU and from 3.0 to 2.3 in the SICU.
From March 2004 to September 2005, 108 ICUs across 67 Michigan hospitals began a multifaceted evidence-based intervention to reduce catheter-associated bloodstream infections (CLABSI) in the Michigan Keystone ICU collaborative. A CUSP team was the first of the interventions that was implemented in order to activate the team for subsequent interventions. Within three months of implementation the median rate of CLABSI's improved to zero from 2.7 CLABSI's per 1000 central line days (p<0.002). Improvements were seen in hospitals regardless of teaching status and number of beds. In this collaborative CUSP was reduced to 6 steps. Safety climate was measured using the SAQ before CUSP was implemented and again 1 year after CUSP. Seventy-two of the 99 ICUs participated in both the baseline and post-CUSP SAQ administration. Response rates were high for both, 75% and 65% respectively. Teamwork climate significantly improved from 46.5% to 50.5%, p<0.005. However, improvements varied with 19 ICU’s increasing teamwork climate by ≥ 10 points while 6 ICU’s had decreasing teamwork climate by ≥ 10 points.

Within the Michigan Keystone Collaborate, in an effort to try to quantify the impact of CUSP on safety climate, team progress barriers and CLABSI, a team checkup tool was created in an attempt to differentiate teams that had implemented CUSP compared to teams that had not implemented CUSP within the Keystone CLABSI Collaborative. ICUs were asked to self-administer the team checkup tool monthly starting 1 year after CUSP implementation and included information on team activities and progress barriers. Monthly reporting rates for the team checkup tool ranged from 51% to 70% in
the first year and declined to 32% to 53% in the second year and 19% to 37% for the last year. Analysis revealed that 60 ICUs used CUSP activities, 17 ICUs did not use CUSP, and 26 ICUs did not have sufficient data to determine the use of CUSP. Safety climate was measured before and after implementation of CUSP among all ICUs, changes in SAQ domains were analyzed and an adjusted difference-in-difference analysis was performed to compare ICUs with and without CUSP. Compared to the non-CUSP ICUs, ICUs that implemented CUSP had statistically significantly greater improvements in safety climate (9.6%, p=0.023), job satisfaction (9.6%, p=0.037), and working conditions domains (9.8%, p=0.032). This represented the first published study to examine the association between successful versus unsuccessful CUSP teams and safety climate.

Long-term follow up for this collaborative revealed that participating ICUs maintained a median CLABSI rate of zero from 19-36 months after implementation. Further study found evidence that this state-wide initiative had an impact on hospital mortality among patients ≥ 65 years old when comparing Keystone participating ICU’s (n=95) to the patients admitted to nearby hospital ICUs in the Midwest region (n=354). Reductions in mortality were greater among Keystone participating ICUs at 12 months (OR 0.83, p=0.041) and at 22 months (OR 0.76, p=0.007) highlighting that CUSP, an intervention to improve safety climate, could contribute to long-term improvements in patient safety and mortality.
From October 2007 to September 2008, a multicenter, phased, cluster-randomized control trial was completed to determine the causal effects of an intervention to reduce CLABSIs in the ICU. This study sought to replicate the interventions in the Michigan Keystone Collaborative and was implemented in 45 ICUs within 35 hospitals and included a further refined 5-step CUSP program. At baseline, mean CLABSI rates were 4.48 and 2.71 (p=0.28) for the intervention and control group, respectively. After 9 months the intervention group CLABSI rate declined to 1.33 compared to 2.16 in the control group (adjusted IRR 0.19, p=0.003, 95% CI 0.06-0.57).

Similar projects have been attempted with an aim to improve ventilator associated pneumonia (VAP). The Rhode Island ICU collaborative implemented CUSP within a multifaceted set of interventions and achieved a 15% reduction in VAP state-wide which was not significantly different than from baseline. Meanwhile another Keystone ICU Collaborative focusing on VAP including 112 ICU’s reduced the median rate of VAP from 5.5 at baseline to 0 at 28-30 months following the intervention (IRR 0.29, p<0.001, 95% CI 0.24-0.34).

In an effort to match the results of CUSP and CLABSI reductions in Michigan, multiple countries have replicated the multifaceted intervention including CUSP at a national level. From April 2008 to June 2010, Spain conducted a prospective time series study including a similar multifaceted set of interventions, including CUSP, across 192 ICUs.
CLABSI rates statistically significantly decreased to a median incidence rate of 1.12 from 3.07 (IRR 0.50, p<0.001, 95% CI (0.39-0.63). From May 2009 to December 2010, the United Kingdom conducted a four-cluster, stepped, non-randomized study of the same multifaceted intervention, including CUSP, that was similar to the study completed in Michigan.\textsuperscript{52} This “Matching Michigan” project adult ICUs mean CLABSI rate statistically significantly decreased from 3.7 at baseline to 1.48 (p<0.0001) at 20 months’ post-implementation.\textsuperscript{52} Pediatric ICUs in the same program mean CLABSI rate decreased from 5.65 to 2.89 (p=0.625). The pediatric ICU’s represented the first published large-scale implementation of this set of interventions that did not achieve statistically significant decreases in CLABSI rates leaving many to wonder why it didn’t work. Finally, from 2009 to 2013, the United States conducted a cohort study using a multifaceted set of interventions, including CUSP, across 1,564 ICUs in 986 hospitals in 44 states, the District of Columbia, and Puerto Rico.\textsuperscript{13} CLABSI rates decreased from 1.96 at baseline to 1.15 after 16-18 months after intervention (adjusted IRR 0.57, 95% CI 0.50-0.65), representing a 43% decreased incidence of CLABSIs.\textsuperscript{13}

**Spreading CUSP Beyond the ICU**

Johns Hopkins Hospital launched its first CUSP teams outside of an ICU in 2003 in the Emergency Department and the medical progressive care unit.\textsuperscript{16} The impact of CUSP on safety climate outside of an ICU was not evaluated until 2008 in an inpatient surgical unit.\textsuperscript{16,17} SAQ teamwork climate and safety climate domain scores were measured using the SAQ before and after implementation of the CUSP program. Both teamwork and
safety domain scores in 2008 had statistically significant (p<0.001) improvements compared to 2006.\textsuperscript{17} This provided evidence that CUSP could impact safety climate outside the confines of an ICU.

In 2008, Johns Hopkins Hospital sought to evaluate the impact their safety program was having on the hospital’s safety culture.\textsuperscript{23} Their safety program included rolling out CUSP in more than 30 units, web-based event reporting, a lessons learned newsletter, patient safety grand rounds, quality and safety journal club, departmental quality and safety dashboards, infrastructure investments, a patient safety budget process, a safety star recognition program, development and implementation of a code of conduct policy and Board of Trustee engagement in patient safety.\textsuperscript{23} Safety climate was measured using the SAQ in 2006 and 2008 and showed statistically significant improvements in all domain scores except stress recognition highlighting that a robust patient safety program across an organization, that included CUSP, can be associated with improved safety climate.

Between July 2009 and July 2011, a peri-operative CUSP team started as part of a multifaceted bundle to improve surgical site infections among the colorectal surgical population.\textsuperscript{18} This represented the first published evidence that CUSP was effective in the peri-operative setting. Surgical site infections were significantly reduced when comparing the one year before CUSP to the one year after CUSP implementation 18.2%
vs. 27.3% respectively, representing a 33.3% decrease (p<0.05, 95% CI 9-58%).\textsuperscript{18}

Addition evaluation revealed a variable direct cost reduction of $955 per case among surgeons participating in CUSP compared to surgeons not participating in CUSP.\textsuperscript{53} Cost savings were found in laboratory work by $191 (p=0.009), operating room utilization by $149 (p=0.05) and supplies by $615 (p=0.003).\textsuperscript{53}

**Contextual Factors Associated with CUSP Implementation**

In an effort to understand the contextual factors associated with success of a quality improvement intervention, the Team Check-up Tool (TCT) was created.\textsuperscript{12,46} This tool was found to be reliable and valid for monitoring team progress using CUSP to improve CLABSI in ICU’s.\textsuperscript{12} The TCT has the potential to serve as a model for developing comparable measures for other team-based interventions.\textsuperscript{12} The TCT is a short instrument that measures participation in intervention components, perceptions of unit performance on infection prevention behaviors and key barriers to team progress including lack of leadership support and physician engagement. Unfortunately, the barriers to team progress did not predict time to zero CLABSI rate but this may have been limited by the variance in CLABSI among the ICU’s included in the study.\textsuperscript{12} Response rate of ICU teams for the monthly TCT was found to be highly variable and low (median= 4 across all ICU-months, min=1, max=15).\textsuperscript{12}

Overwhelmingly CUSP, in combination with technical interventions, has led to significant improvements in clinical outcomes like CLABSI, SSI, VAP and significant improvements in
safety culture including all domains except stress recognition. Unfortunately, not all teams are able to achieve similar improvements and some teams are not able to improve at all. It is not yet understood which team and implementation factors are associated with CUSP success. These factors are important for operational quality and safety leaders who have provided an initial investment in CUSP and are considering spreading this program throughout their organization.

_Team Science: Drawing from the Science of Project Teams_

The CUSP program is designed to bring together a multidisciplinary group of healthcare staff, from frontline staff to senior leaders, in order to identify and learn from defects. CUSP is an intervention to improve safety climate by training staff in the science of safety then allowing them to tackle projects aimed at eliminating preventable harm and improving quality. In essence CUSP is an organizational initiative to implement and sustain unit-level, safety-focused project teams. The fields of project management and of organizational psychology are both interested in the science of teams and together can help us understand factors associated with CUSP team success. 

There is an increasing prevalence of teams in all types of modern organizations, not just in healthcare. Teams have been used to achieve higher levels of process efficiency and outcome efficacy. Meanwhile, projects are the means by which change is brought forth in organizations. As such healthcare generally, and CUSP teams specifically,
could benefit tremendously by incorporating this knowledge in the implementation and sustainability of project teams.

Training all staff in the science of safety is the first critical step in CUSP. Since project teams generally, and CUSP teams specifically, are multidisciplinary, having a shared understanding is critical to success. Team learning results in the change of the status quo, changes behaviors, and causes the team to share knowledge which improves productivity and efficiency. One issue identified with managing project teams is the need to plan for and measure team member churn as team churn can affect project performance. If a CUSP team only trains staff in the science of safety once, just prior to CUSP team kick-off, natural turnover of team members, including the addition of new team members, that are not exposed to this training can dilute team performance and efficiency. As a result, CUSP teams should have a plan in place to train new team members as they are hired and ensure concepts and knowledge are regularly refreshed for experienced team members. These same concepts apply to the project team leader. An initial investment in learning for the CUSP champion is believed to be critical to CUSP team success. Additional opportunities to learn about patient safety and quality improvement methodologies over time should further improve the CUSP champion’s effectiveness. Finally, investing in these learning opportunities any time there is CUSP champion churn will be critical to the sustained success of the team.
Engaging a senior executive is another critical element of CUSP. The presence of a senior executive offers functional diversity to the unit-based team which comprises multiple types of frontline staff. Bunderson and Sutcliffe define functional diversity as a multidimensional construct embracing a variety of differences in individual functional expertise, experience, and knowledge. The CUSP Scorecard includes senior executive and provider or designee attendance as these two roles are identified as important roles that add to the functional diversity of the CUSP team. In particular, these two roles add to the interpersonal functional diversity that adds the breadth of functional diversity at the team level. Interpersonal functional diversity facilitates project team performance because it is associated with increased task conflict and expanding communication and boundaries of project teams. A moderate level of task conflict can improve the quality of team performance by generating ideas, evaluating alternatives, and encouraging constructive criticism. Compared to homogenous teams, task conflict created by functionally diverse teams stimulate creativity and innovation and can enhance the depth of problem evaluation and assessment of options. Functionally diverse teams are more efficient at crossing boundaries to facilitate information transfer and intersect inter- and intra-organizational boundaries. Finally, functionally diverse teams offer a unique advantage to teams by providing multiple sources of communication and networks that enhance project outcomes. In summary, functionally diverse teams demonstrate improved communication, are efficient boundary spanners, and have increased task conflict which are all positively associated with team performance. Collectively, the fields of project management and of
organizational psychology help us understand factors associated with CUSP team success.

Chapter 3: Methods

Research Question

The primary research question guiding this dissertation is: What team and implementation factors are associated with CUSP effectiveness?

Study Aims and Hypotheses

Using the CUSP Scorecard data, we examined the association between the elements of CUSP and safety climate through the following specific aims.

Aim 1: Examine the CUSP team structures and processes that are associated with proximal CUSP team outcomes (total CUSP team projects).

Hypothesis 1: Teams reporting more (a) protected time and (b) training for the team CUSP Champion, and (c) SOS training for staff will report greater provider attendance than those reporting less protected time and training for their CUSP Champion and less training of their staff.

Hypothesis 2: Teams reporting more (a) protected time for the team CUSP Champion, (b) training for CUSP champion, and (c) SOS training for staff will also report greater executive attendance than those reporting less protected time and training for their CUSP Champion and less training of their staff.

Hypothesis 3: Teams reporting more (a) protected time for the team CUSP Champion and (b) training for the champion and (c) SOS training for staff will also
report more meetings held than those reporting less protected time and training for their CUSP Champion and less training of their staff.

**Hypothesis 4:** Teams reporting greater (a) provider and (b) executive attendance and (c) meetings held will also report higher number of CUSP team projects than those reporting less attendance and meetings held.

**Aim 2:** Examine the association between proximal CUSP team outcomes (total CUSP team projects completed) and unit-level safety climate, a distal CUSP team outcome.

**Hypothesis 1:** Teams reporting more total CUSP team projects will also report higher unit-level safety climate scores than those reporting fewer total team projects.

**Aim 3:** Examine the association between the CUSP processes and unit-level safety climate.

**Hypothesis 1:** The relationship between CUSP processes (a) provider and (b) executive attendance and (c) meetings held and unit-level safety climate is partially mediated by the proximal team outcomes.

**Protection of Human Subjects**

This study received approval by the Johns Hopkins University School of Medicine Institutional Review Board on June 10, 2016 (IRB #00103050). To protect the identity of CUSP team members no information on individual member names were included in the database and results were reported in aggregate only.
Study Design

This is an analysis of prospectively collected administrative data on hospital-based CUSP team activities, measured by the CUSP Scorecard, and their association with CUSP effectiveness. The study timeline is as follows (See Figure 3): 1) July 1, 2014 – December 31, 2014 – CUSP team activities; 2) January 1, 2015 – February 28, 2015 – collection of Scorecard data; and 3) March 2015 – collection of data on safety climate measured by the Safety Attitudes Questionnaire. This time period was selected due to the close proximity in time between the CUSP activities collected for this CUSP Scorecard and the safety climate survey assessment.

Figure 3: Data Collection Timeline

Since July 2014, Johns Hopkins Medicine CUSP teams have been asked to fill out CUSP Scorecards on a semi-annual basis. The completion of the CUSP Scorecard is voluntary
and initiated for all teams that are in place for more than 6 months. All active hospital-based CUSP teams in place prior to July 1, 2014 were included in this analysis. This is due to the fact that the CUSP team activities for this scorecard include all activities that occurred between July 1, 2014 – December 31, 2014.

Inclusion Criteria

The study population included all active hospital-based CUSP teams throughout Johns Hopkins Medicine as of July 1, 2014. Using this inclusion criterion, this study included 106 CUSP teams across 2 academic medical centers and 2 community hospitals (see Table 2).

Table 2: Johns Hopkins Hospital-based CUSP Teams by Affiliate as of July 1, 2014

<table>
<thead>
<tr>
<th>Organization Name</th>
<th>Type</th>
<th># of Beds</th>
<th># of CUSP Teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Johns Hopkins Hospital</td>
<td>Academic</td>
<td>1,145</td>
<td>65</td>
</tr>
<tr>
<td>Sibley Hospital</td>
<td>Community</td>
<td>318</td>
<td>28</td>
</tr>
<tr>
<td>Johns Hopkins Bayview Medical Center</td>
<td>Academic</td>
<td>447</td>
<td>7</td>
</tr>
<tr>
<td>Howard County General Hospital</td>
<td>Community</td>
<td>277</td>
<td>6</td>
</tr>
</tbody>
</table>

Exclusion Criteria

Units were excluded if they did not have an active CUSP team in place by July 1, 2014. For example, units that had formally discontinued their CUSP team by notifying their hospital CUSP coordinator of such by July 1, 2014 and teams that had not yet had their 1st CUSP team meeting called their kick-off meeting by July 1, 2014 were excluded. CUSP teams were also excluded if they were not hospital-based. For example, if the
clinic or ambulatory surgery center was associated with a community practice or as a stand-alone center rather than explicitly associated with a hospital.

**Sources of Data**

The data included in these analyses were collected for operational purposes. Data on the number and names of active CUSP teams and their characteristics (ex. kick-off date, CUSP champion name) were collected in an Excel spreadsheet that is maintained in the Armstrong Institute for Patient Safety and Quality’s Patient Safety Department. The CUSP coordinator, who oversees the CUSP program for each affiliate organization, regularly updates this file as new teams are added or in the rare circumstance that teams are discontinued. The date the CUSP team started is defined as the date of the 1st CUSP meeting, what is known as the “kick-off meeting.”

Second, Scorecard data were collected by each CUSP team’s facilitator or the affiliate organization’s CUSP coordinator with each team’s assistance. CUSP coordinators and facilitators have advanced skills and knowledge of CUSP and are external to the individual teams. Verbal and written instructions were provided for all Scorecard measures including a contact person for questions. Data was collected and submitted to the Armstrong Institute for Patient Safety and Quality Patient Safety Department.
As described in chapter one, the CUSP Scorecard was developed to evaluate the progress of CUSP teams in order to help them improve their team performance. Specifically, the Scorecard consists of eight measures, all of which were used in this analysis: The measures include three CUSP team structures (% of staff with Science of Safety training, CUSP champion training and protected time for CUSP champion), three CUSP team processes (% of CUSP meetings held, % of provider attendance and % of executive attendance) and two proximal CUSP team outcomes (# of data-specific improvement projects and # of projects with defects leading to a systems change).

Finally, the safety climate domain data of the Safety Attitudes Questionnaire was collected through online or paper surveys. Specifically, this survey has 7 questions which form the Safety Climate Domain (Table 3). The Armstrong Institute for Patient Safety and Quality contracted with Pascal Metrics® to manage all aspects of the survey administration including the survey creation (paper and online), the database and a web-based platform to conduct basic survey analytics. The Armstrong Institute for Patient Safety and Quality’s Patient Safety Department is the organizational coordinator for all aspects of the safety climate survey and has access to the results for all clinical areas surveyed across Johns Hopkins Medicine.

**Study Variables**

**Unit-level safety climate domain score**
**Definition:** The safety climate domain score for each person was calculated by taking the average score for each person across all items in that domain (7 questions), corrected for negatively worded items. The unit-level safety climate domain score was then calculated as the number of unit members with an individual domain score of ≥4 on a 5-point Likert scale divided by the total number of unit respondents.

**Table 3: SAQ Survey Safety Climate Items**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Survey Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain</td>
<td>Safety climate- Perceptions of a strong and proactive organizational commitment to safety.</td>
</tr>
<tr>
<td>Q1</td>
<td>I would feel safe being treated as a patient.</td>
</tr>
<tr>
<td>Q2</td>
<td>Medical errors are handled appropriately in this clinical area.</td>
</tr>
<tr>
<td>Q3</td>
<td>I know the proper channels to direct questions regarding patient safety in this clinical area.</td>
</tr>
<tr>
<td>Q4</td>
<td>I receive appropriate feedback about my performance.</td>
</tr>
<tr>
<td>Q5</td>
<td>In this clinical area, it is difficult to discuss errors (negatively worded item)</td>
</tr>
<tr>
<td>Q6</td>
<td>I am encouraged by my colleagues to report any patient safety concerns I may have.</td>
</tr>
<tr>
<td>Q7</td>
<td>The culture in this clinical area makes it easy to learn from the errors of others.</td>
</tr>
</tbody>
</table>

**Staff Science of Safety (SOS) knowledge**

**Definition:** Percentage of staff that have completed *Science of Safety* training within past 2 years

**Numerator:** Number of current, permanent staff in the clinical area that have completed Science of Safety Training in the last 2 years.

**Denominator:** Number of current, permanent staff in the clinical area.

**CUSP champion training**
Definition: Unit champion has attended CUSP workshop and Patient Safety Certificate training. (0= no training, 1= has attended CUSP training, 2= has attended both CUSP and Patient Safety Certificate trainings)

Protected time for champion

Definition: Average number of hours per week of protected time for CUSP team champion.

Numerator: Number of dedicated hours on unit champion’s schedule to CUSP work during the designated 6-month period.

Denominator: Number of weeks during the designated 6-month period

CUSP team meetings held

Definition: Percentage of CUSP team meetings held

Numerator: Number of CUSP team meetings held during the designated 6-month period.

Denominator: Number of CUSP team meetings scheduled during the designated 6-month period.

Provider champion attendance

Definition: Percentage of meetings held where provider/designee attends, excluding cancelled meetings

Numerator: Number of meetings provider/designee attends during the designated 6-month period.
Denominator: Number of CUSP team meetings that occurred during the designated 6-month period.

**Executive attendance**

*Definition:* Percent of meetings held where executive attends, excluding cancelled meetings

**Numerator:** Number of meetings executive attends during the designated 6-month period.

Denominator: Number of CUSP team meetings that occurred during the designated 6-month period.

**Defects resulting in a systems change projects**

*Definition:* Number of defects that resulted in a system change where the system change was greater than re-education or discussion only.

**Data-specific improvement projects**

*Definition:* Number of unit-level data-specific improvement projects. These projects were required to include all three of the following: 1) the data being collected; 2) the improvement plan being currently implemented; and 3) the specific goal of project stated.

**Total CUSP team projects completed**

*Definition:* Sum of number of defects resulting in systems-change projects and data-specific improvement projects completed by the CUSP team.

**Age of CUSP team**
**Definition:** Time in months from CUSP team kick-off meeting until 12/31/14.

**Affiliate ID**

**Definition:** Johns Hopkins Medicine affiliate to which CUSP team belongs. (0= Johns Hopkins Hospital, 1=Bayview Medical Center, 2= Sibley Memorial Hospital, 3=Howard County General Hospital)

**Unit Type**

**Definition:** Unit type to which the CUSP team belongs. (0= ICU, 1= inpatient, non-ICU, 2= other)

**Analysis**

The analysis consisted of three phases: 1) creation of a master database combining data from the three data sources previously described; 2) exploratory data analysis and 3) data analysis for each study aim and hypothesis.

**Creation of the master database**

A master database was created from the three data sources that were previously described. Three variables were constructed: 1) total CUSP team projects completed, 2) the age of CUSP team in months and 3) % of total CUSP team projects from data-specific improvement projects. Total CUSP team projects completed was calculated by summing the number of projects that lead to a systems change and the number of projects that were data driven. The percent of total CUSP team projects from data-specific
improvement projects was calculated by dividing the number of data-specific improvement projects by the total CUSP team projects.

Age of CUSP team was calculated by the time, in months, from the date of the CUSP team’s kick-off meeting to December 31, 2014, which represents the end of the period for the scorecard measurement. The exact kickoff date for CUSP teams at Sibley Hospital were not recorded, instead their records indicated that all CUSP teams held their kick-off in Spring 2013. After discussion with their CUSP coordinator, all Sibley CUSP teams were given a CUSP kick-off date of 5/31/13 although their true kick-off date may actually have occurred between 3/1/13 – 5/31/13. In some instances, a CUSP kick-off date was documented as a month and year (ex. 9/2010). In these instances, we used the last day of that month as the day of the kick-off in order to calculate the age of the CUSP team. There were 2 instances where a CUSP team re-kicked off due to their CUSP team stopping work for a long period of time. Although our decision, a priori, was to subtract the dates during the CUSP team’s hiatus from their age, we were unable to do this as there was no documentation for either team that represented when the team officially put a “pause” on their CUSP team. In these two instances the pause lasted 2 years and 11 years. As a result, we used the date of the most recent kick-off to calculate age due to the extensive length of time during the pause.
There were 9 instances in which there was not a one-to-one match with a CUSP team and SAQ data. There were two types of mismatches: one type of mismatch included four CUSP team’s that had more than one safety climate domain score associated with their team. Generally, these are CUSP teams that represented a large clinical area (ex. Emergency Department) where the clinical area was broken into two or more distinct work groups for their safety climate survey. In order to calculate a safety climate domain score for the CUSP team in this analysis, we calculated a weighted average domain score based on the number of respondents that completed the survey in each distinct work group. We also calculated a new response rate for the safety climate survey based on the total respondents that completed the survey across all work groups for that CUSP team as the numerator and the total respondents that were surveyed across all work groups for that CUSP team as the denominator. The second type of mismatch included five teams that used the same safety climate domain score. Generally, these are CUSP teams representing clinical areas that shared staff across two or more areas but had sufficiently distinct safety concerns to justify a CUSP team in each area (ex. inpatient psychiatry unit and an electroconvulsive therapy treatment area). In these instances, we used the safety climate domain score and survey response rate for all of their respective CUSP teams. To test the effect of these decisions on our outcomes we created two additional categorical variables, CUSP teams with a safety climate domain score weighted average and safety climate domain score for multiple CUSP teams, coding each CUSP team if either of these situations were present for the
CUSP team. We then performed sensitivity analyses to look for differences in outcomes with and without these scores.

Exploratory data analysis

We summarized each variable as follows: mean, median, range and standard deviations were assessed for all continuous variables, and counts and percentages were assessed for all categorical variables. We evaluated the distribution of each of the continuous dependent variables proposed in the aims using histograms, normal Q-Q plots, and the Shapiro-Wilk test in order to evaluate the distributions for normality. The dependent continuous variables that were found to be not normally distributed underwent additional procedures, such as log transformation, in order to meet the assumptions necessary for the regression models. We evaluated the distribution of each of the dependent count variables proposed in the aims using scatterplots, histograms, mean, variance and a plot of standardized residuals against estimated expected incidence rates to evaluate for over or under dispersion for a Poisson distribution. For the count variables that were found to not have a Poisson distribution, additional models were used in order to meet the assumptions necessary for the model. Using these procedures, the following describes how we handled the dependent variables that did not meet model assumptions:

CUSP meetings held - Additional procedures, such as log transformation, were not able to transform the data to meet the assumptions for linear regression. Visualization of
the histogram for this data suggested that 2 categories was an appropriate approach.

We then created a new dichotomous variable that included CUSP teams that held <80% of their scheduled meetings and CUSP teams that held ≥80% of their scheduled meetings.

**Provider champion attendance** – Additional procedures, such as log transformation, were not able to transform the data to meet the assumptions for linear regression. Visualization of the histogram for this data suggested that 2 categories was an appropriate approach. We then created a dichotomous variable that included CUSP teams that had <80% of their meetings with a provider champion, or designee, in attendance and CUSP teams that had ≥80% of their meetings with a provider champion in attendance.

**Number of total CUSP team projects**- Due to over dispersion of this data compared to a Poisson distribution, we were not able to meet the assumptions necessary for Poisson regression. As a result, we used a negative binomial model.

Data analysis for each study aim and hypothesis

Multivariate linear regression model (Equation 1), multivariate logistic regression (Equation 2) and multivariate negative binomial regression model (Equation 3) were used for analyses.
Linear regression was used to evaluate the bivariate association between the independent variables and dependent variables outlined above (Table 1) where $x_{i1}$ is the independent variable of interest and $y_i$ is the dependent variable for the $i^{th}$ unit. We included covariates, $x_2 - x_k$, outlined in Table 1 in multivariate linear regression models.

We evaluated each linear regression model for possible influential points using the dfits post-estimation command and evaluated box plots of dbeta statistics for outliers. For observations deemed to be influential based on these plots, in a sensitivity analysis, we excluded these observations and compared the coefficients in the models before and after exclusion of these points to determine if there was any substantial effect. We evaluated for collinearity between variables using the variance inflation factor (vif) post-estimation command and used a threshold of VIF >10 to identify collinearity. We also evaluated Spearman rank correlation coefficients to identify correlations between covariates and used a correlation coefficient of >0.7 as indicating substantial correlation.

Logistic regression (Equation 2) was used to evaluate the bivariate association between independent variables and dependent variables outlined above (Table 1) where $x_{i1}$ is the independent variable of interest and $\log \left( \frac{P(x)}{1-P(x)} \right) = \log \text{odds of } y_i$, the dependent variable.

$$E[y_i|x_i] = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} \ldots \beta_k x_{ik} + \epsilon_i \quad \text{Equation 1}$$

$$\log \left( \frac{P(x)}{1-P(x)} \right) = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} \ldots \beta_k x_{ik} \quad \text{Equation 2}$$
variable for the $i^{th}$ unit. We included covariates, $x_2 - x_k$, outlined in Table 1 in multivariate logistic regression models.

We tested the fit of the logistic regression models using the Hosmer-Lemeshow goodness of fit test using the estat command. We evaluated each logistic regression model for possible influential points by plotting the Pregibon Delta-Beta Influence “dbeta” statistic against the expected linear predictions for each model. We also evaluated box plots of dbeta statistics for outliers. For observations deemed to be influential based on these plots, in a sensitivity analysis, we excluded these observations and compared the coefficients in the models before and after exclusion of these points to determine if there was any substantial effect. We evaluated for collinearity between variables by constructing a bogus multiple linear regression model and using the vif post-estimation command. We also evaluated Spearman rank correlation coefficients to identify correlations between covariates.

$$\log E[d_i|x_i] = \log [n_{i}] + \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} \ldots \beta_k x_{ik} \quad \text{Equation 3}$$

We used Poisson regression (Equation 3) to evaluate the bivariate association between the independent variables and dependent variables outlined above (Table 1) where $x_{i1}$ is the independent variable of interest, $d_i$ represents the number of events observed in the $i^{th}$ unit for $n_i$ unit-months of observation. We included covariates $x_2 - x_k$ outlined in Table 1 in multivariate Poisson regression models.
For Poisson regression models, we evaluated the primary assumption underlying the Poisson model, that mean and variance are equal and used a goodness of fit test to evaluate the fit of the Poisson model. For models not found to meet the assumption (mean = variance or lack of overdispersion) or not found to be a good fit, we used negative binomial regression model to fit these overdispersed count data. The negative binomial model has the same form as the Poisson equation (Equation 3) but with a variance function, $Var(Y_i | x_i) = \mu_i + \alpha \mu_i^2$. It should be noted that the Poisson distribution is a special form of this variance function in which alpha = 0. For models of count data using Poisson or negative binomial regression, we evaluated standardized deviance residuals to identify potential outliers.

To evaluate whether or not the age of the CUSP team modified the relationship between the independent variables (CUSP meetings held <80%, CUSP meetings held ≥80%, provider attendance and executive attendance) and dependent variable (total CUSP projects completed in 6 months), we created an interaction term with age and the independent variable. We then compared the models with the interaction term versus including age as a confounding variable and selected the best model based on the pseudo $R^2$, the Akaike information criterion (AIC) and Bayesian information criterion (BIC).
We aimed to test whether the relationship between CUSP processes (greater provider and executive attendance and greater meetings held) and unit-level safety climate was partially mediated by the proximal CUSP team outcome (number of total CUSP team projects completed) using the Sobel-Goodman mediation test. Mediation is tested by ensuring the following four cases are true: (1) the independent variable significantly affects the mediator, (2) the independent variable significantly effects the dependent variable in the absence of the mediator, (3) the mediator has a significant effect on the dependent variable, and (4) the effect of the independent variable on the dependent variable shrinks upon the addition of the mediator to the model.
Chapter 4: Results

Baseline Characteristics of CUSP teams

One hundred six CUSP teams were active as of July 1, 2014 and included in the analysis. Of the 106 active teams, 88 (83%) submitted scorecard data while 18 (17%) did not. Seventy two of the 106 active CUSP teams were from two academic medical centers while 34 were from two community hospitals. Of the 106 active teams, 16 (15%) were from ICUs, 45 (42.5%) were from non-ICU inpatient units, and 45 (42.5%) were from other types of care areas (e.g. operating rooms, labs, clinics). The majority of active teams (103 of 106) achieved a sufficient response rate to receive unit level results from the patient safety climate survey in March 2015 to (Mean\textsubscript{climatesurveyresponserate} = 73.6%, range = 43% to 120%).

Teams were eligible for inclusion if they submitted scorecard data. We compared the characteristics of eligible and ineligible teams using chi-square analyses in order to evaluate for differences in these teams. There were significant differences ($\chi^2 = 32.15, p < 0.0001$) between the proportion of hospitals that submitted scorecard data versus those that did not submit scorecard data. For example, Howard County General Hospital had 6 CUSP teams and did not submit any CUSP scorecard data, therefore this hospital was the only hospital in the health systems with active CUSP teams that was excluded from the present analyses. There were no significant differences ($\chi^2 = 0.27, p=0.87$) between the proportion of unit types (ICU, non-ICU, other) of teams that submitted scorecard data versus those that did not submit scorecard data. There were no differences (Mean\textsubscript{withscorecard} = 67%, SD = 15% and Mean\textsubscript{noscorecard} = 66%, SD 16%, t = -
0.44, \( p=0.66 \) in the mean safety climate domain score for eligible and ineligible teams, respectively.

Table 4: Characteristics of CUSP Teams, Scorecard and Safety Climate Survey

<table>
<thead>
<tr>
<th></th>
<th>CUSP Teams\textsuperscript{a} N (%)</th>
<th>Included Teams (CUSP Teams with Safety Culture Survey Data and Scorecards Returned) N (%)</th>
<th>Excluded Teams (CUSP Teams with Safety Culture Data and/or No Scorecards Returned) N (%)</th>
<th>p-value \textsuperscript{b}</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Units</td>
<td>106 (100)</td>
<td>88 (83.0)</td>
<td>18 (17.0)</td>
<td>0.000</td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JHH</td>
<td>65 (61.3)</td>
<td>59 (67.0)</td>
<td>6 (33.3)</td>
<td></td>
</tr>
<tr>
<td>BVMC</td>
<td>7 (6.6)</td>
<td>6 (6.8)</td>
<td>1 (5.6)</td>
<td></td>
</tr>
<tr>
<td>Sibley</td>
<td>28 (23.6)</td>
<td>23 (26.1)</td>
<td>5 (27.8)</td>
<td></td>
</tr>
<tr>
<td>HCGH</td>
<td>6 (5.7)</td>
<td>0 (0)</td>
<td>6 (33.3)</td>
<td></td>
</tr>
<tr>
<td>Type of Unit</td>
<td></td>
<td></td>
<td></td>
<td>0.87</td>
</tr>
<tr>
<td>ICU</td>
<td>16 (15.1)</td>
<td>14 (15.9)</td>
<td>2 (11.1)</td>
<td></td>
</tr>
<tr>
<td>Non-ICU</td>
<td>45 (42.5)</td>
<td>37 (42.0)</td>
<td>8 (44.4)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>45 (42.5)</td>
<td>37 (42.0)</td>
<td>8 (44.4)</td>
<td></td>
</tr>
<tr>
<td>Safety Climate (sd)</td>
<td>0.66 (0.15)</td>
<td>0.66 (0.15)</td>
<td>0.65 (0.16)</td>
<td>0.66</td>
</tr>
</tbody>
</table>

\textsuperscript{a} No CUSP teams were missing both safety culture data and scorecards

\textsuperscript{b} Categorical variables compared using chi\textsuperscript{2} and continuous variable compared using t-test

Overview of CUSP Scorecard Data

Among the 88 teams that submitted scorecard data, on average 74% percent of frontline staff on the CUSP team were trained in the science of safety in the past two years, however this varied widely (median = 89%, range: 0% to 100%). Seventeen
percent (n=15) of team champions had not received any training, 63% (n=55) had received CUSP training and 20% (n=18) had received both CUSP training and Patient Safety Certificate training. The average number of hours per week of protected time for the champion was 1.8 hours (median = 1 hour, range: 0 – 20 hours). On average, teams held 83% of their scheduled meetings (median = 84%, range: 17% - 100%). Of the meetings held, a provider attended an average of 66% of those meetings (median = 83%, range: 0% - 100%) and an executive attended 65% of those meetings (median = 78%, range: 0% - 100%). The average age of the team was 3.7 years (median = 1.6, range: 6 months – 13.2 years). Although our decision, a priori, for teams that had stopped meeting for an extended period of time was to subtract the dates during a team’s hiatus from their age, we were unable to do this as there was no documentation that represented when the team officially put a “pause.” In these two instances the pause lasted >2 years. As a result, for these 2 teams we used the date of the most recent kick-off to calculate age. On average teams completed 5.5 projects (median = 5, range: 0 – 18 projects) during the 6 month period from July 1, 2014 through December 31, 2014.

**Aim 1 Hypothesis 1 Results: Provider attendance**

Adjusted multivariate logistic regression analyses (See Table 5) did not detect a significant relationship between protected time for the champion and provider attendance at meetings (OR = 0.9, 95% CI: 0.74, 1.08, p=0.25). Additionally, more science of safety training for staff in the past 2 years was not associated with provider
attendance at meetings (OR = 0.76, 95% CI: 0.15, 3.74, p=0.74). Contrary to the hypothesis, teams whose champions completed CUSP training did not have significantly greater odds of having greater provider attendance compared to teams with champions who did not receive any safety training, (OR = 1.22, 95% CI: 0.27, 5.44, p=0.8).

Compared to teams with champions who did not receive any safety training, teams whose champions received both CUSP basic training and advanced Patient Safety Certificate training had 7.76 times greater odds of having greater provider attendance, however this did not reach statistical significance (OR = 7.76, 95% CI: 0.84, 67.7, p=0.07).

It is noted that only 15 teams had champions that had not received any training and 18 teams had champions receive both types of training which may be an underlying reason for the inprecision of the estimate. Overall, more CUSP champion training was not associated (p=0.12) with greater provider attendance.

There were not significant differences (p=0.43) between hospitals in achieving greater provider attendance. However, there were significant differences (p=0.02) between units types (ICU, non-ICU, other) in achieving greater provider attendance. Non-ICU inpatient units had the lowest odds of having providers attend while the “other” types of units representing procedure areas, operating rooms and clinics had the greatest odds of having providers attend.
In summary, this hypothesis was not supported. There was no association between measured CUSP structures a) protected time for the champion, b) champion training and c) science of safety training and provider attendance.

There was no evidence of collinearity among variables. Four influential points were identified. Upon removing these influential points there were no changes in the significance, or non-significance, of the relationships between the variables compared to when the influential points were included.

Table 5: Factors Contributing to Provider Attendance at CUSP Meetings

<table>
<thead>
<tr>
<th></th>
<th>Crude Odds Ratio</th>
<th>95% CI</th>
<th>P value</th>
<th>Adjusted Odds Ratio</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SOS</strong></td>
<td>0.96</td>
<td>0.25 – 3.62</td>
<td>0.96</td>
<td>0.76</td>
<td>0.15 – 3.74</td>
<td>0.74</td>
</tr>
<tr>
<td><strong>Champion Training</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No training (ref)</td>
<td>0.78</td>
<td>0.24 – 2.54</td>
<td>0.68</td>
<td>1.22</td>
<td>0.27 – 5.44</td>
<td>0.80</td>
</tr>
<tr>
<td>CUSP training</td>
<td>3.25</td>
<td>0.63 – 16.8</td>
<td>0.16</td>
<td>7.76</td>
<td>0.84 – 67.7</td>
<td>0.07</td>
</tr>
<tr>
<td>CUSP + PSC training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protected Time</strong></td>
<td>0.98</td>
<td>0.85 – 1.12</td>
<td>0.72</td>
<td>0.90</td>
<td>0.74 – 1.08</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Hospital</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JHH (ref)</td>
<td>1.41</td>
<td>0.24 – 8.34</td>
<td>0.70</td>
<td>1.65</td>
<td>0.19 – 14.5</td>
<td>0.65</td>
</tr>
<tr>
<td>JHBMC</td>
<td>0.77</td>
<td>0.28 – 2.12</td>
<td>0.62</td>
<td>0.48</td>
<td>0.13 – 1.83</td>
<td>0.28</td>
</tr>
<tr>
<td>Sibley</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unit Type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICU (ref)</td>
<td>0.37</td>
<td>0.10 – 1.34</td>
<td>0.13</td>
<td>0.55</td>
<td>0.10 – 2.87</td>
<td>0.48</td>
</tr>
<tr>
<td>Non-ICU</td>
<td>1.44</td>
<td>0.39 – 5.38</td>
<td>0.58</td>
<td>2.98</td>
<td>0.54 – 16.6</td>
<td>0.21</td>
</tr>
</tbody>
</table>

\(^a\) P value from global test of significance for variable  

\(^b\) P value from global test of significance for variable using Wald test
Aim 1 Hypothesis 2 Results: Executive Attendance

Using multivariate linear regression, after adjusting for other variables (See Table 6), more science of safety training for staff was not significantly associated with greater executive attendance at CUSP meetings (β = 0.11, 95% CI: -0.12, 0.33, p=0.36). More champion training was not associated with executive attendance at meetings (p=0.80). More protected time for the champion was not associated with greater executive attendance at meetings (β=-0.002, 95% CI: -0.03, 0.03, p=0.87). There were not significant differences between hospitals (p=0.81) or unit types (p=0.47) in achieving greater executive attendance.

Overall, hypothesis two was not supported. There was no association between measured CUSP structures (a) protected time for champion, (b) champion training and (c) science of safety training and executive attendance.

There was no evidence of collinearity among variables. Three influential points were identified. After removing these influential points there were no changes in the significance, or non-significance, of the relationships between the variables compared to when the influential points were included.
Table 6: Factors contributing to Executive Attendance at CUSP Meetings

<table>
<thead>
<tr>
<th></th>
<th>Crude ß Coef</th>
<th>95% CI</th>
<th>P value</th>
<th>Adjusted ß Coef</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOS</td>
<td>0.10</td>
<td>-0.11 – 0.30</td>
<td>0.36</td>
<td>0.11</td>
<td>-0.12 – 0.33</td>
<td>0.36</td>
</tr>
<tr>
<td>Champion Training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No training (ref)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUSP training</td>
<td>0.02</td>
<td>-0.16 – 0.20</td>
<td>0.82</td>
<td>0.01</td>
<td>-0.20 – 0.21</td>
<td>0.95</td>
</tr>
<tr>
<td>CUSP + PSC training</td>
<td>-0.01</td>
<td>-0.23 – 0.21</td>
<td>0.92</td>
<td>-0.06</td>
<td>-0.31 – 0.20</td>
<td>0.66</td>
</tr>
<tr>
<td>Protected Time</td>
<td>0.003</td>
<td>-0.02 – 0.02</td>
<td>0.75</td>
<td>-0.002</td>
<td>-0.03 – 0.03</td>
<td>0.87</td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JHH (ref)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JHBMC</td>
<td>0.02</td>
<td>-0.25 – 0.29</td>
<td>0.88</td>
<td>-0.09</td>
<td>-0.40 – 0.22</td>
<td>0.58</td>
</tr>
<tr>
<td>Sibley</td>
<td>-0.05</td>
<td>-0.20 – 0.10</td>
<td>0.52</td>
<td>-0.04</td>
<td>-0.22 – 0.13</td>
<td>0.64</td>
</tr>
<tr>
<td>Unit Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICU (ref)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-ICU</td>
<td>-0.08</td>
<td>-0.28 – 0.12</td>
<td>0.45</td>
<td>-0.14</td>
<td>-0.38 – 0.09</td>
<td>0.23</td>
</tr>
<tr>
<td>Other</td>
<td>-0.04</td>
<td>-0.24 – 0.16</td>
<td>0.70</td>
<td>-0.13</td>
<td>-0.37 – 0.10</td>
<td>0.27</td>
</tr>
</tbody>
</table>

*aP value from global test of significance for variable

bP value from global test of significance for variable using Wald test

Aim 1 Hypothesis 3 Results: CUSP Meetings Held

Adjusted multivariate logistic regression analyses (See Table 7), did not detect a significant relationship between protected time for the champion and holding regular meetings (OR = 0.98, 95% CI: 0.81, 1.18, p=0.8). More champion training was not associated with holding regular meetings (p=0.30). More science of safety training for staff in the past 2 years was not associated with the odds of having regular meetings (OR = 2.60, 95% CI: 0.48-14.2, p=0.27).
There were significant differences between hospitals \((p=0.03)\) in the odds of having regular CUSP meetings. Compared to Johns Hopkins Hospital, Johns Hopkins Bayview Medical Center had a 0.14 lower odds of having regular meetings \((OR = 0.14, 95\% CI: 0.01, 1.50, p=0.10)\). Compared to Johns Hopkins Hospital, Sibley Hospital had a 0.14 lower odds of having regular meetings which was significantly different \((OR = 0.14, 95\% CI: 0.03, 0.6, p=0.008)\). There were not significant differences \((p=0.97)\) among unit types (ICU, non-ICU inpatient, other) in the odds of having regular meetings.

Overall, this hypothesis was not supported. There was no association between CUSP structures a) protected time for champion, b) champion training and c) science of safety training and meetings held.

There was no evidence of collinearity among variables. There were 5 influential points identified. After removing these influential points there were no changes in the significance, or non-significance, of the relationships between the variables compared to when the influential points were included.

**Table 7: Factors Contributing to CUSP Meetings Held**

<table>
<thead>
<tr>
<th></th>
<th>Crude Odds Ratio</th>
<th>95% CI</th>
<th>P value</th>
<th>Adjusted Odds Ratio</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOS</td>
<td>1.71</td>
<td>0.40 – 7.25</td>
<td>0.47</td>
<td>2.60</td>
<td>0.48 – 14.2</td>
<td>0.27</td>
</tr>
<tr>
<td>Champion Training</td>
<td></td>
<td>0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td>0.30&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>No training (ref)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Adjusted for SOS and P value < 0.05.
Aim 1 Hypothesis 4 Results: Total CUSP Team Projects

For this Poisson regression model, the primary assumption underlying the model, that mean and variance are equal, was not met. Total projects completed, the dependent variable, had a mean of 5.53 projects per 6 months while the variance was 12.8, indicating that this count data was overdispersed. To further analyze the model fit, we also tested the goodness of fit for each of the bivariate analyses for the dependent variable, total CUSP projects completed (See Table 8). For each of the bivariate analyses the large value of the chi-square and the significant test statistic ($p<0.05$) indicated that the Poisson model was inappropriate. As a result, we then used the negative binomial regression model to fit these overdispersed count data.
Upon visual inspection of the relationship between the percent of scheduled CUSP meetings that were held and total projects completed in 6 months, using lowess, there was a marked change in slope at 80% of meetings held. As a result, a spline term was added with one knot at 80% of meetings held which allowed for the relationship between meetings held and total projects to vary for teams with less than 80% of their meetings and those with 80% or more of their meetings held.

Including an age x process interaction term (where the processes were executive attendance, provider attendance and CUSP meetings held) did not improve the fit of the model over only including age as a confounding variable (See Table 9).
Table 9: Model fit for total projects completed with age as a confounder compared to adding an age x process interaction term

<table>
<thead>
<tr>
<th>Process</th>
<th>Model adjusting for age</th>
<th>Previous model plus an interaction term for age$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R2</td>
<td>AIC</td>
</tr>
<tr>
<td>CUSP Meetings Held$^b$</td>
<td>0.07</td>
<td>396</td>
</tr>
<tr>
<td>Provider Attendance</td>
<td>0.07</td>
<td>396</td>
</tr>
<tr>
<td>Executive Attendance</td>
<td>0.07</td>
<td>396</td>
</tr>
</tbody>
</table>

$^a$ Interaction term for age x process where process was CUSP meetings held, provider attendance, or executive attendance

$^b$ CUSP meetings held modeled using a spline term with a knot at 80%

After adjusting for other variables (See Table 10), the multivariate negative binomial regression model showed that provider attendance was inversely associated with total projects completed (IRR = 0.59, 95% CI: 0.41, 0.84, $p=0.009$). There was no association seen between executive attendance and the total projects completed (IRR = 1.13, 95% CI: 0.71, 1.80, $p=0.61$). Among CUSP teams with less than 80% of their meetings held there was no association with total projects completed (IRR = 1.02, 95% CI: 0.3, 3.52, $p=0.96$) but among teams with 80% or greater of their meetings held, for every 1 percentage point increase in meetings held there was an 8.33 fold increase in total CUSP projects completed (IRR = 8.33, 95% CI: 1.71, 40.4, $p=0.009$).

After adjusting for other variables, for every 1 month increase in age of the team there was a 0.3% increase in total projects completed (IRR = 1.003, 95% CI: 1.000, 1.007,
\( p=0.03 \). In other words, for every 1 year increase in age of the CUSP team there was a 3.6\% increase in total CUSP projects completed.

The number of projects completed did not differ significantly by hospital \(( p=0.19 \) or unit-types \(( p=0.17 \).

In summary, hypothesis four was partially supported. There were significant associations between two CUSP processes (meetings held and provider attendance) and total CUSP projects completed. There was no association detected between executive attendance and total projects completed.

For models of count data using Poisson or negative binomial regression, we evaluated standardized deviance residuals to identify potential outliers. After removing influential points there were no changes in the significance, or non-significance, of the relationships between the variables compared to when the influential points were included.

### Table 10: Factors Contributing to Total CUSP Projects Completed

<table>
<thead>
<tr>
<th></th>
<th>Crude IRR</th>
<th>95% CI</th>
<th>P value</th>
<th>Adjusted IRR</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meetings Held &lt;80%</td>
<td>0.87</td>
<td>0.27-2.85</td>
<td>0.82</td>
<td>1.02</td>
<td>0.3-3.52</td>
<td>0.96</td>
</tr>
<tr>
<td>Meetings Held ≥80%</td>
<td>10.32</td>
<td>2.27-46.9</td>
<td>0.003</td>
<td>8.33</td>
<td>1.71-40.4</td>
<td>0.009</td>
</tr>
</tbody>
</table>
**Additional Analyses: Provider Attendance and Total CUSP Projects Completed**

To further explore the significant inverse relationship between provider attendance and total projects completed, additional analyses were conducted. In this database, total projects completed was the sum of completed data-driven improvement projects and completed defects resulting in systems change projects. Since provider attendance had a negative impact on the total projects completed by teams we sought to understand if this was due to a higher proportion of completed data-driven improvement projects which by definition are more robust projects than the defects resulting in a systems
change projects. We created a new variable that represented the proportion of data-driven improvement projects to total projects completed and evaluated if teams reporting higher provider attendance also reported more robust projects.

Using multivariate linear regression, after adjusting for other variables (See Table 11), there was not an association between provider attendance and the proportion of data-driven improvement projects completed ($\beta = -0.03$, 95% CI: -0.2, 0.13, $p=0.69$). For every 1 hour per week increase in protected time for the CUSP champion, there was a 2% increase in the proportion of data-driven improvement projects completed although it was only marginally significant ($\beta = 0.02$, 95% CI: -0.001, 0.04, $p=0.06$).

There was no evidence of collinearity among variables. There were seven influential points identified. After removing these influential points there were no changes in the significance, or non-significance, of the relationships between the variables compared to when the influential points were included.

Table 11: Factors Contributing to the Proportion of Data-driven Improvement Projects Completed

<table>
<thead>
<tr>
<th></th>
<th>Crude beta coef.</th>
<th>95% CI</th>
<th>P value</th>
<th>Adjusted beta coef.</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provider attendance</td>
<td>-0.042</td>
<td>-0.18-1.0</td>
<td>0.55</td>
<td>-0.03</td>
<td>-0.2-0.13</td>
<td>0.69</td>
</tr>
<tr>
<td>Executive attendance</td>
<td>0.003</td>
<td>-0.17-0.18</td>
<td>0.97</td>
<td>0.04</td>
<td>-0.17-0.25</td>
<td>0.69</td>
</tr>
</tbody>
</table>
Aim 2 and Aim 3 Results: Safety Climate Domain Scores

Using multivariate linear regression, after adjusting for other variables (See Table 12), there was no association between total projects completed and the team’s safety climate domain score ($\beta=-0.001$, 95% CI: -0.01, 0.01, $p=0.82$). There was no association seen between holding regular meetings and the team’s safety climate domain score ($\beta=-0.07$, 95% CI: -0.27, 0.13, $p=0.49$). There was not an association between provider attendance and the team’s safety climate domain score ($\beta=0.01$, 95% CI: -0.10, 0.10, $p=0.90$) or executive attendance and the team’s safety climate domain score ($\beta=0.02$, 95% CI: -0.10, 0.14, $p=0.69$).
The teams’ safety climate domain scores did not significantly differ by hospital ($p=0.28$) or unit-types ($p=0.31$).

In summary, this aim two hypothesis was not supported. There was no association seen between the either the CUSP processes (executive attendance, provider attendance, and meetings held) or the proximal CUSP team outcome (total projects completed) and the team’s safety climate domain score.

There was no evidence of collinearity among variables. There were 3 influential points identified. After removing these influential points there were no changes in the significance, or non-significance, of the relationships between the total projects and safety climate scores compared to when the influential points were included. However, after removing the influential points there was a significant association between unit-type and safety climate domain score ($p=0.02$) suggesting lower scores for non-ICU inpatient units compared to ICUs.

<table>
<thead>
<tr>
<th></th>
<th>Crude ß Coef.</th>
<th>95% CI</th>
<th>P value</th>
<th>Adjusted ß Coef.</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total CUSP Projects</strong></td>
<td>-0.0002</td>
<td>-0.01 – 0.01</td>
<td>0.97</td>
<td>-0.001</td>
<td>-0.01 – 0.01</td>
<td>0.84</td>
</tr>
<tr>
<td>CUSP Meetings Held &lt;80%</td>
<td>-0.03</td>
<td>-0.32 – 0.27</td>
<td>0.85</td>
<td>-0.06</td>
<td>-0.4 – 0.29</td>
<td>0.74</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------</td>
<td>--------------</td>
<td>------</td>
<td>--------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>CUSP Meetings Held ≥80%</td>
<td>-0.03</td>
<td>-0.43 – 0.37</td>
<td>0.88</td>
<td>-0.09</td>
<td>-0.56 – 0.38</td>
<td>0.70</td>
</tr>
<tr>
<td>Provider Attendance</td>
<td>-0.01</td>
<td>-0.09 – 0.08</td>
<td>0.88</td>
<td>0.01</td>
<td>-0.09 – 0.10</td>
<td>0.91</td>
</tr>
<tr>
<td>Executive Attendance</td>
<td>0.04</td>
<td>-0.07 – 0.14</td>
<td>0.48</td>
<td>0.02</td>
<td>-0.10 – 0.14</td>
<td>0.69</td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JHH (ref)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>JHBMC</td>
<td>-0.09</td>
<td>-0.21 – 0.02</td>
<td>0.11</td>
<td>0.01</td>
<td>-0.29 – 0.04</td>
<td>0.14</td>
</tr>
<tr>
<td>Sibley</td>
<td>-0.001</td>
<td>-0.07 – 0.07</td>
<td>0.07</td>
<td>0.01</td>
<td>-0.07 – 0.10</td>
<td>0.77</td>
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<td>Unit Type</td>
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<td></td>
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<tr>
<td>ICU (ref)</td>
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<tr>
<td>Non-ICU</td>
<td>0.05</td>
<td>-0.04 – 0.14</td>
<td>0.26</td>
<td>0.02</td>
<td>-0.10 – 0.13</td>
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<tr>
<td>Other</td>
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<td>-0.10 – 0.08</td>
<td>0.77</td>
<td>-0.05</td>
<td>-0.16 – 0.07</td>
<td>0.42</td>
</tr>
</tbody>
</table>

*P value from global test of significance for variable

| Hospital               |        |              |      |        |             |      |
| JHH (ref)              |        |              |      |        |             |      |
| JHBMC                  | -0.09  | -0.21 – 0.02 | 0.11 | 0.01   | -0.29 – 0.04 | 0.14 |
| Sibley                 | -0.001 | -0.07 – 0.07 | 0.07 | 0.01   | -0.07 – 0.10 | 0.77 |
| Unit Type              |        |              |      |        |             |      |
| ICU (ref)              |        |              |      |        |             |      |
| Non-ICU                | 0.05   | -0.04 – 0.14 | 0.26 | 0.02   | -0.10 – 0.13 | 0.78 |
| Other                  | -0.01  | -0.10 – 0.08 | 0.77 | -0.05  | -0.16 – 0.07 | 0.42 |

Mediation

Mediation is tested by ensuring the following four cases are true: (1) the independent variable significantly affects the mediator, (2) the independent variable significantly effects the dependent variable in the absence of the mediator, (3) the mediator has a significant effect on the dependent variable, and (4) the effect of the independent variable on the dependent variable shrinks upon the addition of the mediator to the model.  

In Aim 1 (See Table 11), we identified that there was a significant effect of meetings held (independent variable) and provider attendance (independent variable) on total CUSP
projects completed (mediator). There was not a statistically significant effect of executive attendance (independent variable) on total CUSP projects completed (mediator).

In Aim 2 and Aim 3 (See Table 12) we identified that there was not a statistically significant effect of meetings held (independent variable), executive attendance (independent variable) and provider attendance (independent variable) on the CUSP team’s safety climate domain score (dependent variable). And there was not a statistically significant effect of total CUSP projects completed (mediator) on the CUSP team’s safety climate domain score (dependent variable).

As a result, these findings do not support the proposed mediation hypothesis that CUSP processes (a) provider and (b) executive attendance and (c) meetings held and unit-level safety climate are partially mediated by the proximal CUSP team outcome (total CUSP projects completed).
Chapter 5: Discussion and Implications

Discussion

This dissertation began to examine the team and implementation factors associated with CUSP effectiveness using a transdisciplinary framework combining team theory and implementation science. Specifically, secondary analyses of operational data from a large, multi-hospital health system (88 CUSP teams followed over a 6-month time period) were used to examine the associations between specific CUSP team structures, processes, proximal outcomes, and the distal outcome of unit-level patient safety climate.

Overall, we found that higher provider attendance at meetings was associated with a significantly lower total number of projects completed, and the total number of projects completed was not associated with safety climate domain scores. We also found that when the percentage of meetings held was above 80%, there was an association between meetings held and total projects completed and that there was no association between meetings held and total projects completed when the percentage of meetings held was lower than 80%. Otherwise, no CUSP team structures or other processes were associated with proximal (total CUSP projects completed) or distal (safety climate domain) outcomes.
The finding that provider attendance was inversely associated with the number of projects completed was unexpected, and additional analyses indicated that provider attendance was not associated with the “type” of project (rate-based preventable harm projects vs. non-rate based preventable harm projects). The scientific literature on teams may help to clarify this finding by suggesting that teams with more provider attendance would represent an increase in functional diversity of the CUSP team. This functional diversity could potentially increase task conflict, stimulate innovation, and enhance the depth of project evaluation and assessment of options.25,60-62 These benefits may inherently lengthen the time for each project to be completed which would have the consequence of reducing the total number of CUSP projects completed in 6 months compared to less functionally diverse teams. The literature also suggests that functionally diverse teams may produce superior performance (i.e., improvement projects of higher quality or addressing more difficult issues) which would not necessarily be quantified in the count of the total number of CUSP projects completed over 6 months. Interestingly, these findings did not extend to the relationship between executive attendance and the total number of CUSP projects completed where we did not find an association. More research is necessary to understand the differences between the projects that functionally diverse CUSP teams complete versus the projects completed by more homogenous CUSP teams.

Even though there was no overall association seen between meetings held as a continuous variable and total projects completed, we did find a very strong association
between the proportion of scheduled meetings held and number of projects completed for teams who held 80% or more of their meetings. For CUSP teams that held 80% or more of their scheduled CUSP meetings, we found an 8.33-fold increase in the total number CUSP projects completed for every one percentage point increase in the percentage of meetings held. However, for CUSP teams that held less than 80% of their scheduled CUSP meetings, we found no association between the proportion of meetings held and the number of projects they completed. This finding suggests that holding at least 80% of meetings scheduled is a marker of CUSP team performance as it predicts a major CUSP goal, project completion. We explored this further and did not find any CUSP structures (science of safety training, CUSP champion training, and protected time for the champion) to be significantly associated with the percentage of meetings held in our study.

We did find a suggestion of organizational factors that may contribute to a higher percentage of meetings held. Compared to Johns Hopkins Hospital, the other two hospitals who submitted CUSP Scorecard data had lower odds of having regular meetings ($p=0.03$). Johns Hopkins Bayview Medical Center has 2 different unit-based safety programs in their organization. Each unit at Bayview engages in executive safety rounds while only 6 units have both executive safety rounds and CUSP teams. According to their safety leaders, their organizational priority is executive safety rounds which may be a main reason underlying the lower percentage of CUSP meetings held at this site. In contrast, Sibley Hospital has placed a priority on their CUSP program. In 2013, their
President initiated the CUSP program and implemented it across 28 clinical areas. In speaking with their safety leaders, they indicate that there was insufficient organizational support for CUSP champions in their first year to help them in setting up a successful CUSP program locally. They believe this was a main driver for there being an 86% lower odds of having ≥80% of their scheduled CUSP meetings compared to Johns Hopkins Hospital (p=0.008). These results and additional information from local leaders indicate that there may be numerous factors that contribute to differences between organizations in their CUSP programs. Additional research in this area will benefit hospitals in understanding the organizational factors associated with a successful CUSP program.

Although there was no evidence indicating that age modifies the relationship between CUSP processes, we examined meetings held, provider attendance, executive attendance and the number of projects completed. We found that age of the team was independently associated with the total number of projects completed. To our knowledge this represents the first study to identify this relationship. We did not measure processes around communication and decision-making and the absence of an interaction between age of the team and the processes measured suggests that unmeasured processes, such as executive engagement rather than attendance, may be important and should be considered in the future.
We did find a small, though non-significant association ($p=0.11$) between increased protected time for the CUSP champion and the total number of CUSP team projects completed, but the level of protected time was very low in this sample (median = 1 hour per week). This is likely insufficient protected time to have an impact on the total number of CUSP team projects complete over a 6 month period. This relationship became stronger when we evaluated the type of projects completed. We found a small, non-significant association ($p=0.06$) between protected time for the CUSP champion and the proportion of data-driven improvement projects completed by the CUSP team but not for other projects (i.e., non-rate-based preventable harm projects).

Surprisingly, we did not find an association between total CUSP projects completed (proximal CUSP outcome) and the distal outcome of unit-level safety climate domain scores nor did we find an association between CUSP team processes (meetings held, executive attendance and provider attendance) and unit-level safety climate domain scores. Multiple explanations likely underlie the observed absence of associations. First, the number of total CUSP projects may not be the right proximal CUSP team outcome to characterize eventual CUSP success. The absolute number of CUSP projects completed may be insufficient to summarize the work of the CUSP team, and the actual quality of projects may matter instead of simply the number of projects completed. Furthermore, we evaluated total projects completed over a 6-month period, a duration which may not be significant enough to impact safety climate domain.
Second, total CUSP projects completed may be associated with the change in unit-level safety climate scores over a specific interval of time rather than the absolute unit-level safety climate domain score. Most literature to date has used the change in safety climate scores over a given interval as the distal measure of success of CUSP teams. Future analyses should consider evaluating the association between total CUSP projects completed and the change in safety climate domain score from the previous survey period.

Third, safety climate domain scores may be impacted by other events that are affecting the clinical area or organization other than the work of the CUSP team. For example, if there were organizational initiatives, like a hiring freeze on nursing positions, that had a negative impact on the perceptions of safety climate, these may have a stronger effect on the safety climate domain scores than the work of the CUSP team. In this study, we did not collect data on these types of organizational or unit-level events.

Finally, the literature to date has only described CUSP’s impact on safety climate for 18 months following CUSP implementation. There is no evidence to date that CUSP has an impact on improving safety climate longitudinally beyond 18 months. This is a critical gap in the evidence examining CUSP. The teams in this sample had an average age of 3.7 years, ranging from 6 months to 13.2 years. One potential explanation for our findings could be that CUSP improves safety climate after its initial implementation.
and then the program serves to recalibrate and set the safety culture at a new level which could introduce the possibility of a “ceiling” effect. As a result, additional interventions beyond CUSP may be necessary to continue to improve safety climate scores in the long term. CUSP may also serve to make the safety culture more resilient in the long term, and the safety climate survey may not be the most appropriate way to measure resilience. Additional research on the impact of CUSP to clinical units longitudinally will be critical to demonstrating the continued impact CUSP has on a clinical area locally and the organization broadly.

In this study, we also evaluated the associations between CUSP structures and processes. For provider attendance, we did not find protected time for the CUSP champion to be predictive, but protected time was generally low (median of 1 hour per week).

Lastly, regular provider attendance at CUSP meetings varied by unit type. Non-ICU inpatient units (compared to ICU’s and other types of units) had the lowest odds of regular provider attendance. Importantly, non-ICU inpatient units rarely have a physician leader associated with the unit and more often have multiple services that admit to them. This can create a situation where it is difficult for the CUSP team to identify a provider to serve as their designated champion. The “other” category of CUSP teams in this sample are primarily operating rooms, procedure areas and ambulatory clinics. Contrary to the non-ICU inpatient units, these units often have very strong
provider/physician participation and leadership. Identifying opportunities for providers to take leadership responsibilities in non-ICU inpatient units may facilitate provider attendance at CUSP meetings. This represents an important organizational finding that the leadership must work to overcome.

We did not find any of the measured CUSP structures, processes, or organizational factors (hospital or unit type) to be associated with executive attendance at CUSP meetings. Executives attended, on average, 65% of CUSP meetings (median = 78%, range 0% - 100%). This variation suggests other factors likely contribute to executive attendance at CUSP meetings. Executives tend to be extremely busy with both scheduled meetings and urgent meetings that arise with short notice that require missing previously-scheduled meetings. Also, CUSP teams may be working to schedule CUSP meetings that may be convenient for clinicians to attend but less convenient for executives. For example, one unit holds their CUSP meetings on a rotating time of 7am on even months and 7pm on odd months. While these times are convenient to engage clinicians, particularly nurses, it requires an executive to extend their day and may prevent the executive from fully participating. More work must be done to explore the underlying factors associated with executive attendance in CUSP meetings. Regardless, executive attendance was not associated with proximal or distal outcomes.
**Strengths and Limitations**

There are several strengths and limitations to this study. Generalizability may be limited as this analysis only included teams within one health system. However, since CUSP is an intervention at a unit-level, and our data include units in academic and community hospitals, our findings may be generalizable across a variety of settings (clinical areas with a community or academic hospital, including ambulatory clinics, operating rooms and laboratories) in which CUSP teams could occur in hospital settings. Another limitation is that these analyses do not include a comparison or control group. Since CUSP penetration is so extensive within this health system, it was not possible to include a comparison or control group comprised of comparable units that had not implemented the CUSP intervention. For example, in two hospitals in this sample, CUSP was implemented in all inpatient clinical units. In addition, since the CUSP Scorecard is very specific to the CUSP program, collecting CUSP Scorecard data would not make sense in units that do not have a CUSP program in place. A lack of a comparison group limits the inferences that can be made from our findings, particularly it limits our ability to eliminate alternative explanations for our findings. As noted above, many of these analyses may be limited by small sample size (i.e., they may be underpowered to determine if an association actually exists and also limited in their ability to provide precise estimates). For example, for CUSP champion training, 55 champions had CUSP training, but only 15 and 18, had no training or CUSP training plus Patient Safety Certificate training, respectively.
There are several strengths of our study. We used standardized data collection tools. CUSP team data, CUSP Scorecard data and safety climate data were collected using standardized data collection tools. We used clearly defined metrics. The CUSP Scorecard metrics were developed by a team of clinicians and researchers with extensive expertise in CUSP and measurement. Also, this study has operational importance. Much of the research published to date on CUSP implementation focuses on how well a single clinical quality initiative has been implemented (ex. CLABSI, SSI, VAP). Therefore, this study enables understanding, from an operational perspective, of the factors associated with CUSP success for teams tackling a diverse range of safety and quality issues across a broad range of clinical settings.

**Implications & Conclusions**

This dissertation examined the team and implementation factors associated with CUSP effectiveness using a transdisciplinary framework combining team theory and implementation science. In particular, we did not find that the total number of projects completed by a CUSP team to be associated with safety climate domain scores. Regarding CUSP processes, we did find that provider attendance at CUSP meetings and the percentage of CUSP meetings held were associated with the total number of projects completed, however results for provider attendance were not in the anticipated direction. Surprisingly, we found that higher provider attendance at CUSP meetings was associated with a lower total number of CUSP projects completed,
suggesting that there are other important factors to consider such as the quality of projects completed. Also, we only found that the percentage of meetings held was associated with a higher number of total projects completed if the percentage of meetings held was at least 80%. We also identified organizational factors that may be important to the success of CUSP.

Additional research is needed to further understand and validate our findings. Critical research questions that should be explored include the following: What is the long-term impact of CUSP on safety climate? Is there a better proximal outcome for CUSP team effectiveness than the number of total CUSP projects that have been completed and if so, what is that outcome? What are other important CUSP team structures and CUSP team processes that are associated with CUSP team effectiveness? A variety of research methods will be needed to answer these questions. Qualitative studies are needed to determine other proximal outcomes that reflect CUSP team effectiveness and to identify other CUSP team structures and processes that are associated with CUSP team effectiveness. Ultimately, this qualitative work and our quantitative work need to be followed up by longitudinal studies including larger samples from health systems already implementing CUSP across the US to confirm our findings and to answer questions about the long-term effectiveness of CUSP, including on clinical outcomes.
Most immediately with these findings, we can recommend the following: Organizations should work to identify and support providers in taking leadership responsibilities in non-ICU inpatient units. CUSP teams should be encouraged and supported in holding all scheduled CUSP meetings. CUSP teams who meet less than 80% of their scheduled meetings should work to identify and correct the underlying causes of meeting cancellations. Ensure all CUSP champions have received CUSP training. Consider providing additional advanced training to CUSP champions. Hospital leaders should work to understand how their local implementation and support of the CUSP program impacts CUSP teams. CUSP teams who are younger should have lower goals in terms of the number of total projects completed compared to CUSP teams that are older. Provide additional protected time to CUSP champions to achieve a higher proportion of rate-based preventable harm projects.

More broadly this dissertation provides early insights on team and implementation factors associated with CUSP effectiveness and lays the groundwork for future work in this area. Understanding these factors are key to allowing organizations to appropriately support and resource their CUSP program in order to improve their culture of safety. Achieving a robust culture of safety is a necessary but insufficient step to eradicate preventable harm and become a highly reliable industry on par with the airline industry or air craft carriers. It is only when we become much more highly reliable that we will be able to deliver on the promise to our patients and policy makers to deliver the best quality of care, every single time at the lowest possible cost.
References


33. Vogus TJ, Sutcliffe KM. The impact of safety organizing, trusted leadership, and care pathways on reported medication errors in hospital nursing units. Med Care 2007;45:997-1002.


# APPENDIX A: CUSP SCORECARD

<table>
<thead>
<tr>
<th>Measure</th>
<th>UNIT A</th>
<th>UNIT B</th>
<th>UNIT C</th>
<th>UNIT D</th>
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<tr>
<td>1 Percentage of staff that have received <em>Science of Safety</em> training within past 2 years as of 12/31/14 (%)</td>
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<td>2 Unit champion has attended CUSP Workshop and <em>AI Patient Safety Certificate Program</em> as of 12/31/14</td>
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<tr>
<td>3 Average number of hours per week of protected time for unit champion from 7/1/14 - 12/31/14</td>
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<td>4 Percentage of CUSP meetings held during the evaluation period of 7/1/14 - 12/31/14 (%)</td>
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<td>5 Percentage of CUSP meetings with provider champion/designee present during the evaluation period of 7/1/14 - 12/31/14 (%)</td>
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<td>6 Percentage of CUSP meetings with senior executive present during the evaluation period of 7/1/14 - 12/31/14 (%)</td>
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<td>7 Number of defects learned from during the evaluation period of 7/1/14 - 12/31/14</td>
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<td>8 Number of unit-data specific improvement projects completed during the evaluation period of 7/1/14 - 12/31/14</td>
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APPENDIX B: CURRICULUM VITAE

CURRICULUM VITAE
March 5, 2017
Melinda D. Sawyer, MSN, RN, CNS-BC

DEMOGRAPHIC INFORMATION

Current Appointments

2017- present  Director, Patient Safety and Education, Armstrong Institute for Patient Safety and Quality, The Johns Hopkins University, School of Medicine
2017-present  Director, Patient Safety, The Johns Hopkins Hospital
2012-present  Director, Armstrong Institute for Patient Safety and Quality Leadership Academy, The Johns Hopkins University, School of Medicine
2015-present  Oversight of Learning & Development Department, Armstrong Institute for Patient Safety and Quality, The Johns Hopkins University, School of Medicine
2015-present  Chair, Educational Development Council, Armstrong Institute for Patient Safety and Quality, The Johns Hopkins University, School of Medicine
2015-present  Joint Appointment, The Johns Hopkins University, School of Nursing

Personal Data

1800 Orleans St.
Carnegie 667
Baltimore, MD 21287
Phone: 443-756-0408 (cell)
Email: msawyer1@jhmi.edu

Education

2009  M.S.N, Clinical Nurse Specialist, The Johns Hopkins University, School of Nursing, Baltimore, MD

2012-present  D.r.P.H.- candidate, Healthcare Leadership and Management, Department of Health Policy and Management, The Johns Hopkins University Bloomberg, School of Public Health, Baltimore, MD, expected graduation: May 2017

**Professional Experience**

1999-2000  Clinical Nurse Intern, Halsted 4, Department of Medicine, The Johns Hopkins Hospital, Baltimore, MD

2000-2005  Nurse Clinician IIIE, Medical Progressive Care Unit, Department of Medicine, The Johns Hopkins Hospital, Baltimore, MD

2005-2008  Nurse Coordinator, Department of Medicine, The Johns Hopkins Hospital, Baltimore, MD

2008-2012  Patient Safety Officer, Department of Medicine, The Johns Hopkins Hospital, Baltimore, MD

2008-2012  Senior Research Coordinator, The Quality and Safety Research Group, Johns Hopkins University, School of Medicine, Baltimore, MD

2012- 2017  Assistant Director, Patient Safety, Armstrong Institute for Patient Safety and Quality, The Johns Hopkins University, School of Medicine

2012-2017  Assistant Director, Patient Safety, The Johns Hopkins Hospital

2012-present  Director, Armstrong Institute for Patient Safety and Quality Leadership Academy, The Johns Hopkins University, School of Medicine

2015-present  Oversight of Learning & Development Department, Armstrong Institute for Patient Safety and Quality, The Johns Hopkins University, School of Medicine

2015-present  Chair, Educational Development Council, Armstrong Institute for Patient Safety and Quality, The Johns Hopkins University, School of Medicine

2017-present  Director, Patient Safety, The Johns Hopkins Hospital

2017-present  Director, Patient Safety and Education, Armstrong Institute for Patient Safety and Quality, The Johns Hopkins University, School of Medicine

**RESEARCH ACTIVITIES**
Publications

Peer-reviewed


**Extramural Sponsorship**

2008-2011 National Implementation of the Comprehensive Unit-based Safety Program (CUSP) to Reduce Central Line Associated Bloodstream Infections (CLA-BSI) in the Intensive Care Unit
Sponsor: Agency for Healthcare Research and Quality/Health Research and Education Trust
ID Number: Contract
PI: Peter Pronovost, MD, PhD
Role: Senior Research Coordinator

2011-present Implementation of the Comprehensive Unit-based Safety Program (CUSP) to Reduce Central Line Associated Bloodstream Infections (CLA-BSI) in the Naval Medical Centers
Sponsor: Department of Defense/Johns Hopkins Applied Physics Lab
ID Number: Contract
PI: David Thompson, RN, ScD
Role: Content/Subje ct Matter Expert, Trainer

Sponsor: Department of Defense/Johns Hopkins Applied Physics Lab
ID Number: Contract
Role: Developer and Faculty Lead

**EDUCATIONAL ACTIVITIES**

**Book Chapters**

### Teaching

#### Classroom Instruction

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<td>2009-2010</td>
<td>Effective Transition to the Clinical Nurse Specialist Role, course faculty, one semester each year</td>
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<td>2010-2012</td>
<td>The Science of Patient Safety, course faculty, one semester each year</td>
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<td>The Johns Hopkins University, School of Nursing</td>
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<td>2011-present</td>
<td>Learning from Defects, TIME Safety Course, winter intersession</td>
<td>course faculty</td>
<td>The Johns Hopkins University, School of Medicine</td>
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<td>2012-present</td>
<td>Eliminating Central Line-Associated Bloodstream Infections: A Case Study</td>
<td>course faculty, two semesters each year</td>
<td>The Johns Hopkins University, School of Nursing</td>
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<td>2012-present</td>
<td>Expanded roles and opportunities for the Clinical Nurse Specialist and Advanced Practice Nurse</td>
<td>course faculty</td>
<td>University of Maryland, School of Nursing</td>
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<tr>
<td>2015-present</td>
<td>Technical and Adaptive Challenges in Implementation Science</td>
<td>course faculty, 4th quarter</td>
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#### Clinical Instruction

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<td>2006</td>
<td>Dealing with Difficult People, Department of Medicine, Nursing Coordinators</td>
<td>Department of Medicine, Nursing Coordinators</td>
<td>The Johns Hopkins Hospital</td>
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<td>2007</td>
<td>Department of Medicine Admission Processes, Clerical Associates Annual Review</td>
<td>Clerical Associates</td>
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<td>2008</td>
<td>Science of Improving Patient Safety, Clinical Associates</td>
<td>Department of Medicine, Clinical Associates</td>
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<td>2008-2012</td>
<td>Science of Improving Patient Safety, Department of Medicine residents, once per year</td>
<td>Department of Medicine, residents</td>
<td>The Johns Hopkins University, School of Medicine</td>
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<td>2009</td>
<td>Safe Use of Medications</td>
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<td>2009-present</td>
<td>Science of Improving Patient Safety, SPRING Program for new Nurses</td>
<td>SPRING Program for new Nurses</td>
<td>The Johns Hopkins Hospital</td>
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<td>2010</td>
<td>Central Line Associated Bloodstream Infections: A Review of the CDC Guidelines</td>
<td>Department of Medicine</td>
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#### CME/CNE Instruction

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<td>2009</td>
<td>On the CUSP: Stop BSI Pre-Mortem and Debrief</td>
<td>Connecticut Hospital Association</td>
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2009  On the CUSP: Stop BSI Pre-Mortem and Debrief, New Jersey Hospital Association  
2009  On the CUSP: Stop BSI Pre-Mortem and Debrief, Georgia Hospital Association  
2009  On the CUSP: Stop BSI Pre-Mortem and Debrief, Indiana Hospital Association  
2009  On the CUSP: Stop BSI Pre-Mortem and Debrief, Oregon Hospital Association  
2009  Central Line Maintenance, Michigan Hospital Association ICU Collaborative, Detroit, MI  
2012  Streamlining the STAT Medication Process: An Interdisciplinary Quality Improvement Project, Johns Hopkins Medicine Patient Safety Summit  
2012  Streamlining the stat medication process through an observational study and utilization of automated dispensing cabinets (ADCs): An interdisciplinary quality improvement project in an academic medical center, ASHP National Conference, Las Vegas, Nevada  
2013  The Role of the Clinical Nurse Specialist in Reducing National Central Line Associated Bloodstream Infection Rates, NACNS National Conference, San Antonio, TX  
2015  Examining variation in nurses’ mental models of influence and leadership. Panel presentation at the 30th annual meeting of the Society for Industrial and Organizational Psychology; April 2015; Philadelphia, PA. 

Workshops  
2010-2014  The Comprehensive Unit-based Safety Program 2-day workshop, four times per year, The Armstrong Institute for Patient Safety and Quality  
2013-present  Patient Safety Certificate Program, 5-day, four times per year, The Armstrong Institute for Patient Safety and Quality  
2014-present  Foundations of CUSP, online workshop, The Armstrong Institute for Patient Safety and Quality  
2014-present  Applications of CUSP, 1-day workshop, fifteen times per year, The Armstrong Institute for Patient Safety and Quality  

Mentoring
2010  Carey Cezar, MSN, RN
Reducing time to STAT medication administration;
Clinical Nurse Specialist student preceptor;
Present Position: Nurse Clinician IIE, Labor and Delivery, The Johns Hopkins Hospital

2010-2011  Nush Ahluwalia, MSN, RN
Reducing time to STAT medication administration;
Clinical Nurse Specialist student preceptor
Present Position: Clinical Nurse Specialist and President, Chesapeake Bay Chapter of the National Association of Clinical Nurse Specialists

2011  Cindy Ellis, MSN, RN
Implementation of a Systems Change Report in the Department of Medicine;
Clinical Nurse Specialist student preceptor
Present Position: Clinical Nurse Specialist, Greater Baltimore Medical Center

2013-2014  Tanvir Hussain, MD, MHS
Achieving Blood Pressure Control in an Ambulatory Setting
Present Position: Assistant Professor, General Internal Medicine;
Medical Director, Quality and Analytics, Nebraska Medicine

2013-present  Christine Robson, MSN, RN, CNRN
Reducing Falls in the Department of Neuroscience;
Clinical Nurse Specialist student preceptor
Present Position: Senior Project Analyst, The Johns Hopkins Hospital

2014-present  Samantha Pitts, MD, MPH
Translation of the Comprehensive Unit-based Safety Program to the ambulatory setting
Present position: Assistant Professor of Medicine, Johns Hopkins University, School of Medicine; Johns Hopkins KL2 Clinical Research Scholar

2015-present  Amy Plotts, MSN, RN
Building a national cohort model for implementation and sustainability of CUSP
Present Position: Patient Safety Innovation Coordinator, The Johns Hopkins Hospital and the Armstrong Institute for Patient Safety and Quality, Johns Hopkins University School of Medicine

CLINICAL ACTIVITIES

License and Certification

2000-present Registered Nurse, Maryland Board of Nursing
2010-present Clinical Nurse Specialist-Board Certified, American Nurse Credentialing Center
2012-present Advanced Practice Registered Nurse Clinical Nurse Specialist, Maryland Board of Nursing
2004-2010 Progressive Care Registered Nurse, American Association of Critical-Care Nurses
2008-2012 Basic Life Support Certification, Instructor
2008-2012 Advanced Life Support Certification, Instructor

Clinical Responsibilities

2000-2005 Nurse Clinician IIE, Medical Progressive Care Unit, Department of Medicine, The Johns Hopkins Hospital, Baltimore, MD
2005-2008 Nurse Coordinator, Emergency Code Team Nurse Lead, Department of Medicine, The Johns Hopkins Hospital, Baltimore, MD
2010-present Per-Diem Nurse, Medical Progressive Care Unit, Department of Medicine, The Johns Hopkins Hospital, Baltimore, MD

SYSTEM INNOVATION AND QUALITY IMPROVEMENT ACTIVITIES

System Innovation and Quality Improvement Efforts Within JHM

2003 Timely delivery and administration of medications
2003 Initiation of multidisciplinary rounds on the medical progressive care unit
2003  Initiation of the comprehensive unit-based safety program on the medical progressive care unit

2004  Web-based tool for the comprehensive unit-based safety program

2004  Improving IV tubing change compliance on the medical progressive care unit

2004  Improving nurse-physician communication through the use of two-way text pagers

2008  Implementation of a monthly patient safety committee for nursing in the department of medicine

2009  Safe medication practices in the cardiovascular interventional lab

2009-2010  *Harnessing the multidisciplinary team and available technology to reduce patient falls on a telemetry unit

2010  Streamlining STAT medication management in the inpatient setting

2010-present  Dynamic indicators of suspected poor outcomes (DISPO) study to identify patients in the medical progressive care unit who are transferred to the MICU within 12 hours of admission

2012-present  Evaluating the short and long term outcomes of the implementation of a quality and safety leadership program within a large health system

2012-present  Implementation of health system structure to support the rapid and sustained growth of the comprehensive unit-based safety program in each JHM affiliate

2013-present  Development, implementation, and evaluation of a quality scorecard for the comprehensive unit-based safety program

2013-present  Provider behavior research group: examining the relationships between safety culture, provider behavior, and clinical outcomes

2014-present  *Reducing the use of telemetry and cardiac monitor alarms in the department of medicine through the application of an evidenced-based checklist

2014-present  Implementation of a standardized IV tubing label across Johns Hopkins Hospital

*Winner of the Johns Hopkins Hospital Nursing Excellence Awards (2011, 2015)

System Innovation and Quality Improvement Efforts Outside JHM

2010-2012  Improving safety of medical devices through simulation and applying systems engineering principles and best practices; collaboration with the Applied Physics Lab and FDA, Baltimore, MD
2013-2015  The Frequency of Intravenous Medication Errors Related to Smart Infusion Pumps: A Multi-Hospital Observational Study; collaboration with Partners Healthcare and AAMI, Boston, MA

2014-present  The World Health Organization (WHO) African Partnership for Patient Safety: Kiwoko Hospital, Uganda, projects on medical waste segregation, surgical site infections and medication safety; collaboration with the WHO

**Educational Program Building and Leadership**

2012-present  Director & Founder, Armstrong Institute for Patient Safety and Quality Leadership Program, 9-month multidisciplinary, health system, quality and safety training program that develops future leaders in quality and patient safety, to date have trained 88 scholars.


2016-present  Developer, Resident Quality and Safety Training Curriculum, Johns Hopkins Bayview Medical Center, Department of Medicine Residency Program

2016-present  Director and Co-founder, Navy Medicine Patient Safety and Quality Leadership Academy, United States Navy Bureau of Medicine and Surgery; Chief Medical Officer, Patient Safety Officer and Quality Officer training program across all Navy Military Treatment Facilities

**ORGANIZATIONAL ACTIVITIES**

**Institutional Administrative Appointments**

2002-2005  Scheduling Committee, chair, Medical Progressive Care Unit, The Johns Hopkins Hospital

2003-2005  Comprehensive unit-based safety unit, unit champion, Medical Progressive Care Unit, The Johns Hopkins Hospital

2008-2012  Communication Committee, member, Department of Medicine Nursing, The Johns Hopkins Hospital

2008-2012  Performance Improvement Committee, co-chair, Department of Medicine Nursing, The Johns Hopkins Hospital
2008-2012 Quality Improvement Committee, member, Department of Medicine, The Johns Hopkins Hospital
2008-2012 Patient Safety Committee, member, Department of Medicine, The Johns Hopkins Hospital
2008-2012 Continuity of Care, member, The Johns Hopkins Hospital
2008-present Hopkins Event Action Team (HEAT), member, The Johns Hopkins Hospital
2008-present Significant Medication Events, member, The Johns Hopkins Hospital
2008-present Medication Event Reduction Improvement Team, member, The Johns Hopkins Hospital
2008-present Patient Safety Committee, The Johns Hopkins Hospital
2009-2011 Vascular Access Committee, member, The Johns Hopkins Hospital
2010-2012 All Safety Meeting, chair, Department of Medicine Nursing, The Johns Hopkins Hospital
2010-2012 Patient Safety Summit, member, The Johns Hopkins Medicine
2011-2012 Vascular Access Device Committee, member, The Johns Hopkins Hospital
2012-present Patient Safety Summit, chair, The Johns Hopkins Hospital
2012-present Patient Safety & Quality Improvement Council, member, The Johns Hopkins Hospital
2012-present MICU CUSP facilitator, The Johns Hopkins Hospital
2012-present Nelson 8 CUSP facilitator, The Johns Hopkins Hospital
2013-present Medication Safety Clinical Community, member, The Johns Hopkins Medicine
2014-present Ambulatory Quality and Safety Committee, member, The Johns Hopkins Hospital
2014-present Green Spring Station Internal Medicine Clinic CUSP facilitator, The Johns Hopkins Hospital
2015-present EPIC Ambulatory Design Workgroup, member, The Johns Hopkins Medicine
2015-present EPIC Headers & Banners Workgroup, chair, The Johns Hopkins Medicine
2015-present Quality & Safety in the Learning Environment, member, The Johns Hopkins Hospital

Editorial Activities
Journal Review
2008-present  Critical Care Nurse

Professional Societies
2004-2010  American Association of Critical Care Nurses, member
2006-present  Sigma Theta Tau International, member
2009-present  National Association of Clinical Nurse Specialists, member
2010-present  Chesapeake Bay Chapter, National Association of Clinical Nurse Specialists, member
2011-2012  Chesapeake Bay Chapter, National Association of Clinical Nurse Specialists, President-elect
2012-2013  Chesapeake Bay Chapter, National Association of Clinical Nurse Specialists, President
2013-2014  Chesapeake Bay Chapter, National Association of Clinical Nurse Specialists, Immediate Past President

RECOGNITION
Awards, Honors
1995-1999  McGowin Nursing Scholarship
2005  Johns Hopkins Hospital Osler Medical Staff Housestaff Appreciation Award
2006  Sigma Theta Tau Nursing Honor Society
2009  Ruth Dale Ogilby Award for exceptional academic excellence, The Johns Hopkins University, School of Nursing
2011  Nursing Excellence Award, The Johns Hopkins Hospital
2014  John C. Hume Doctoral Award for showing great potential in the field of public health, The Johns Hopkins University, Bloomberg School of Public Health
2015  Nursing Excellence Award, The Johns Hopkins Hospital

Invited Talks, Panels
2010 On the CUSP: Culture and Teamwork, Proven Clinical Improvement, Missouri Center for Patient Safety Learning Together Conference, Jefferson City, MO

2010 Evidenced-Based Care for Central Line Maintenance, Michigan Hospital Association Keystone Center Annual Conference, Lansing, MI

2011 The Comprehensive Unit-based Safety Program, Agency for Healthcare Research & Quality Annual Conference, Bethesda, MD

2011 The Comprehensive Unit-based Safety Program, North Mississippi Health System Patient Safety Summit (Baldrige Award winning hospital), Tupelo, MS

2012 CUSP Bootcamp, Florida Hospital Association Annual Patient Safety Conference, Orlando, FL

2013 The State of Ordinary in Healthcare, FMQAI Annual Patient Safety Conference, Tampa, FL

2014 The Comprehensive Unit-based Safety Program: Creating a Culture of Safety to Reduce Hazards in Healthcare, Chief Naval Officer Strategic Studies Group, Naval War College, RI


2015 Nurse Leadership Cohort: Patient Safety, Clinica Las Condes, Santiago, Chile

2016 A Game, an App, and an Incident Report for Safety Education. Panel presentation at the American Society of Anesthesia Educators Annual Spring meeting. Baltimore, MD

2016 Organizing for Quality and Patient Safety. Department of Patient Safety and Quality Grand Rounds Penn State University – Hershey Medical Campus, Hershey, PA


2016 Culture Change for the Implementation of Quality Improvement – Fifth Annual Johns Hopkins Critical Care and Rehabilitation Conference, Division of Pulmonary and Critical Care Medicine and Department of Physical Medicine and Rehabilitation, Baltimore, MD
2017  CUSP: An Adaptive Intervention to Improve Patient Safety Culture. Keynote Speaker, Annual Patient Safety Summit, University of Miami Medical Center, Miami, FL

2017  Technical and Adaptive Skills to Eliminate Preventable Harm, Keynote Speaker – Annual Patient Safety Conference, Kaweah Delta Health Care District, Fresno, Cal

2017  Organizing for Quality and Patient Safety within a Highly Reliable Framework. Keynote Speaker, Moinhos de Vento Hospital, Porto Alegre Brazil