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Improving Disinfectant Cap Use on Central Lines in the ICU to Reduce Patient Risk for CLABSI: A Quality Improvement Project

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Abstract

BACKGROUND: Central line-associated bloodstream infections (CLABSI) are the most common type of preventable healthcare-associated bloodstream infection, and may increase length of stay (LOS), facility treatment costs, and patient mortality rates. Intensive Care Unit (ICU) patients are especially vulnerable to CLABSI due to their critical health conditions and other comorbid factors. A literature review provided evidence supporting the use of alcohol-impregnated disinfectant caps, such as SwabCap®, on central line (CL) ports to significantly reduce patients' risk for CLABSI. This quality improvement project took place within an adult ICU of a Level II trauma facility in New England, where the Infection Prevention (IP) team's weekly ICU audit data showed use of these caps on patient's CLs to be inconsistent and trending negatively from February to May 2021. In recent 2022 audits, cap use on CLs was still <100%, with 78% in March and 80% in April. This project focused on improving CL capping protocol adherence in the ICU from <100% to 100% to reduce patients' risk for CLABSI and maintain this microsystem's CLABSI rate of zero throughout 2022.

METHODS: The Plan, Do, Study, Act (PDSA) framework was used to guide this QI process and improve CL disinfectant cap protocol adherence in the ICU. A tick-and-tally survey was conducted among 19 staff nurses to determine barriers, revealing that 84% regarded lack of convenient cap access as the main reason for poor protocol adherence. The intervention was developed based on this information. Outcome data on percentage of CLs appropriately capped and intervention participation were then gathered throughout June 2022 via weekly IP audits.

INTERVENTION: To improve cap accessibility, staff were encouraged to hang one cap bag on each CL patient's IV pole and replace it as-needed. This intervention was introduced during two change-of-shift huddles and via a staff-wide email and six informative pamphlets hung throughout the unit. Staff and leadership meetings were also scheduled throughout the project to reinforce participation.

RESULTS: The project goal of 100% appropriate cap use was not met, with cap use averaging 75% in June, a decrease from the 78% recorded in March and 80% in April. Intervention consistency on the unit was also low after implementation, averaging 69% in June. However, the microsystem did not experience any CLABSI events and staff/leadership verbalized that they felt the intervention was helpful in overcoming barriers to cap accessibility.

CONCLUSIONS: Limitations of this project included the lack of intervention consistency, competing stakeholder priorities, and infrequent IP audits (occurring only once a week) which reduced the amount of data for analysis. Further study is recommended to evaluate staff's qualitative response suggesting this project was helpful in overcoming identified barriers, since the quantitative data did not show an associated improvement. Staff should be resurveyed to identify strengths/weaknesses of the project, and other barriers that may have contributed to the decrease in protocol adherence should be explored to develop and modify the intervention for the next PDSA cycle.

Keywords: Central Line Associated Bloodstream Infection (CLABSI), alcohol-impregnated disinfectant cap, central line, infection prevention, Intensive Care Unit (ICU)

Introduction

Central venous catheters (CVC), or central lines (CL), are intravenous (IV) catheters placed into large veins for various acute or critical care purposes, including long-term venous access, infusion of multiple medications, nutritional support, and hemodialysis. These lines have a larger diameter than peripheral IVs and often have two to four lumens to allow for multiple, simultaneous medication infusion. Central lines are typically inserted into one of three large central veins: the internal jugular vein (IJ), subclavian vein (SCL), or femoral vein. Peripherally inserted central catheters (PICC) are another type of central line, but they are inserted into a vein in the upper arm which reaches the brachiocephalic trunk or subclavian vein (Leib et al., 2021). CVCs are longer than peripheral IVs, with the catheter terminating in a large vein near or just inside the heart, allowing them to stay in place for weeks to months without causing irritation.

While CVCs can be extremely useful in facilitating patient care, they also introduce the risk of complications that can be both dangerous to the patient and costly to treat. Central line-associated bloodstream infections (CLABSI) are infections that develop when bacteria or other microorganisms enter a patient's bloodstream through their central line. According to the Joint Commission (2022), CLABSI are the most common type of healthcare-associated bloodstream infection; in fact, five to twenty six percent of patients will experience infectious bloodstream complications related to their central line (McGee & Gould, 2003). These infections endanger patient wellbeing and may result in an increase in length of hospital stay, facility treatment costs, and patient mortality rates (McGee & Gould, 2003).

CLABSI incidents not only adversely affects hospitals' reputations but also their finances. Each year, treatment for CLABSI can cost the U.S. health care system between $300 million and $2 billion (Ranji et al., 2007). According to the Agency for Healthcare Research and

Quality (AHRQ), the cost of treating CLABSI may average $48,108 per episode for a facility, making this type of infection one of the most expensive hospital-acquired infection (HAI) (2017). Additionally, the occurrence of a CLABSI may prevent insurance reimbursement for healthcare costs related to treatment. On July 31, 2008, the Centers for Medicare & Medicaid Services (CMS) established that hospitals will no longer be compensated for select patient conditions that were not present on admission, or HAIs (2021). Since CLABSI are considered preventable infections, the financial responsibility for both treating this infection and accommodating the patient's extended length of stay falls solely on the hospital. As a result, financial incentive likely plays a role in a facility's motivation to prevent CLABSI in addition to their desire to optimize patient outcomes.

Aside from being costly, CLABSI can also be incredibly deadly, with over 28,000 deaths resulting each year (Haddadin et al., 2020). This type of infection has a reported mortality rate of 7-27%, with an excess mortality rate of 15% (adjusted for underlying mortality) (AHRQ, 2017). A 10-30% absolute increase in mortality for Intensive Care Unit (ICU) patients has also been linked to CLABSI; however, it is possible that this higher risk for death could also be attributed other underlying morbidities in this specific population (Ranji et al., 2007).

While reducing rates of HAI such as CLABSI is important in all areas of a healthcare facility, it may be the most vital in critical care settings, such as the ICU, due to these patients' extreme vulnerability. Ranji et al. (2007) estimate that 25-30% of all HAIs occur in ICU patients due to the presence of comorbid conditions. Among all HAIs, this population is at a particularly high risk of developing CLABSI as a result of their compromised immune systems, long-term central line use, and frequent/repeated CVC access (Marschall et al., 2014). Based on data from Centers for Disease Control and Prevention (CDC), ICU patients specifically may be at higher

risk of developing a CLABSI overall, with 30,000 out of 80,000 yearly CLABSI episodes in the United States occurring in the ICU alone (2021). With roughly 50-80% of critically ill patients requiring a central line at some point during their stay, the risk of CLABSI in this population increases daily (Govindan et al., 2018).

Problem Description

On reviewing internal data from the ICU of a 220-bed, level II trauma center in New England, CL maintenance in this microsystem showed room for improvement, with an overall goal of reducing patient risk for CLABSI (Appendix A). This hospital's ICU data revealed a total of four CLABSI occurrences in 2019 (one in February, two in May, and one in July), no occurrences in 2020, two occurrences in 2021 (one in April and one in August), and no occurrences so far in 2022. The microsystem's CLABSI Standard Infection Ratios (SIR) were as follows: 1.44 in 2019, with 2,835 reported CL days, and 2.78 predicted CLABSI; and 0.00 in 2020, with 2,543 CL days and 2.49 predicted CLABSI (NH Division of Public Health Services [NHDPHS], 2021; Internal Data, 2022). The ICU data on SIR, CL days, and predicted CLABSI for 2021 have not yet been finalized, but the hospital-wide SIR for CLABSI in 2021 was 0.222. According to the Infection Prevention (IP) team, the CLABSI SIR for the ICU will likely be higher, but still < 1.0. The national benchmark for CLABSI SIR is 1.0, and the organizational SIR goal is < 0.447. Overall, this microsystem met the organizational and national goals in 2020 but not 2019.

Data related to CLABSI in this ICU is collected and tracked by the IP team through the review of provider documentation and via weekly audits during which each patient with a CL is visited and their line/dressing checked. Safe line maintenance is monitored during these audits, including ensuring each CL has an alcohol-impregnated disinfectant (orange) cap and checking

whether the dressing is clean/dry/intact and appropriately dated. Subsequently, any deficits are noted and communicated to nursing staff in order to resolve the issue.

Leadership on the unit is also involved in this audit process through participation in daily meetings with IP, during which all patients with CLs are identified and type of line, indication, and possibility of removal were discussed. The Nurse Manager then accompanies the IP representative on weekly rounds/audits to check dressings and update nurses if standards are not met. There is currently no checklist for nurses to follow regarding proper CL maintenance; however, organization policy provides information on CL maintenance requirements (such as clean/dry/intact dressing, insertion date, and disinfectant cap), and education regarding CLs and CLABSI risk is provided by IP on a yearly and "as needed" basis.

Insertion, maintenance, and removal are aspects of CL use that provide opportunity for bacteria to enter the bloodstream and cause CLABSI (CDC, 2014). To promote safe insertion and removal, central lines in this microsystem can only be placed and discontinued by provider order, and the radiology department must perform the insertion. The ICU nurses follow protocols to encourage safe line maintenance, including practicing hand hygiene and wearing clean gloves before touching the line, using chlorohexidine (CHD) antiseptic daily to cleanse patients' skin, reviewing line indications daily (and removing them if they are deemed unnecessary), performing dressing/line changes in a timely manner, maintaining appropriate dressing status, cleansing access ports with alcohol or CHD, and applying alcohol-impregnated disinfectant caps when the line is not in use. The IP team then performs weekly audits on patients to ensure that these protocols are being properly followed to reduce infection risk.

One check that is done during these audits is for the use of SwabCap® alcohol-impregnated disinfectant caps on central line ports. IP data shows that disinfectant cap use was

inconsistent and trending negatively from February to May 2021, with 100% use in February, 90% in March, 85% in April, and 87% in May (Appendix A). In the recent 2022 ICU CL audits, cap use on CLs that were not currently running drips use was 78% in March and 80% in April (Appendix D). This inconsistency in CL maintenance may leave ICU patients with these lines at higher risk of CLABSI.

Available Knowledge

PICO Question

The following PICO question was developed to guide the literature review for this project: In adult (18+) hospital patients with CLs (P: patient/population), how does the use of alcohol-impregnated disinfectant caps on CLs not in continuous use (I: intervention), compared to manual or non-antiseptic methods (C: comparison), affect rates of CLABSI (O: outcome)?

Search Strategy

In April 2022, an electronic search was conducted according to this PICO question to review evidence related to the use of alcohol-impregnated disinfectant caps on central lines to reduce risk for CLABSI in adult patients. The search was conducted using the databases PubMed and the Cumulative Index of Nursing and Allied Health Literature (CINAHL) which were searched using combinations of the key words/phrases “disinfectant cap,” “CLABSI,” and “central line.” The search was limited to full-text, English-language articles that were published no earlier than 2012. Results were filtered to eliminate publications that were abstract-only, non-English, older than ten years, and non-scholarly/peer-reviewed.

A total of 37 articles were identified; after removing duplicates, 26 were screened by title and abstract and 10 full-text articles read completely to assess their eligibility. Articles were considered for inclusion if they contained research on the use of alcohol-impregnated

disinfectant caps on CLs in adult hospital patients to reduce risk of CLABSI, and used CLABSI rates to measure efficacy of the intervention. Articles were excluded if they explored disinfectant cap use on non-central lines, involved non-adult or outpatient populations, examined disinfectant caps only as one part of a bundle, and/or focused on prevention of other HAI in addition to CLABSI. Ultimately, five articles were selected for appraisal in this review, each of which was assigned a grade/strength of recommendation to determine its quality and applicability using the *Evidence Pyramid - Levels of Evidence* (n.d.) research evidence appraisal tool.

Appraisal of Evidence

Jimenez et al. (2015) performed a systematic review of nine quasi-experimental studies to summarize evidence regarding the effectiveness of alcohol-infused disinfectant caps in preventing CLABSI compared to manual disinfection like *scrubbing the hub*. The studies reviewed evaluated the use of these caps for passive central line port disinfection among the adult inpatient population. This systematic review of quasi-experimental studies provided Level 5 evidence for this appraisal. Through their review, Jimenez et al. (2015) found that all studies reviewed demonstrated anywhere from a 30-87% reduction in CLABSI rates after the implementation of the disinfectant caps. These results showed that, compared to manual CL port disinfection methods such as *scrubbing the hub* or no disinfection at all, the disinfectant caps were considerably more effective in reducing CLABSI rates. Going forward, the authors recommended the use of disinfectant caps on CL ports while not actively in-use to limit patients' risk of CLABSI.

Öğülmen & Ateş (2020) also found the use of alcohol-containing disinfectant caps to be beneficial in preventing CLABSI. These researchers organized a single-blind, randomized controlled trial—providing Level 2 evidence for this review—to investigate the use of these caps

in preventing CLABSI among patients at a coronary intensive care unit (CICU) in a cardiovascular surgical hospital. For this study, 95 patients aged 65 or older met the researchers' inclusion criteria and were asked to participate. These patients were randomly and blindly assigned to one of two groups, either an intervention group (n= 47) or control group (n= 48), through block randomization. The intervention group had alcohol-impregnated caps placed on their CL ports while not in-use to provide passive disinfection of the needle-free connectors; the control group received standard catheter caps without a disinfecting agent. To gather infection data, patients reporting chills or presenting with temperatures less than 36°C or higher than 38°C were followed-up with and cultures were taken to assess for the presence of a CLABSI.

Throughout this study, data was collected using a CLABSI tracking form prepared by the researchers to gather information on patient demographics, length of stay, type of CL, date of insertion, vital signs, presence of infection symptoms (e.g., chills, fever, etc.), and culture results in the case of a suspected infection. A program called "SPSS 25" was used for data analysis, allowing the researchers to calculate a relative risk statistic for CLABSI in each group. Results of this study showed a statistically significant ($p < 0.001$) difference in CLABSI risk between the two groups, with infection risk in the control group 13.7 times higher than that of the intervention group. These findings supported the idea that disinfectant caps on CLs while not in-use may be beneficial in preventing CLABSI. The authors' recommendation, therefore, was to use these caps consistently to prevent CL port contamination when not accessing these lines.

Some limitations of this study were that the patients involved were all aged 65+, making it difficult to apply the findings generally, and that CL dressing types varied among the patients. Catheter dressing type (either gauze or chlorohexidine-infused) can be a risk factor for CLABSI, raising the concern that this aspect of the patients' CL maintenance may have affected the results

of the study. While the number of patients using each type of dressing were made equal between groups to account for this factor, the authors still deemed this as a limitation. Otherwise, the authors declared no conflicts of interest and received no financial support for the article's creation/publication, reducing any risk of bias that might lower the evidence quality.

Palkar et al. (2016) performed a retrospective observational study—providing Level 4 evidence for this review—that assessed the incidence of CLABSI at St John's Episcopal Hospital in Queens, NY, before and after the introduction of 70% isopropyl alcohol disinfectant caps for CL maintenance. All adult patients with CLs at this hospital were included in the study. During Phase 1, occurring from January 2013 to February 2014, the researchers assessed baseline CLABSI rates prior to introducing the disinfectant caps. Blood cultures were also collected from all patients during this phase in order to identify out any pre-existing bloodstream infections. Phase 2 was then implemented in February 2014, with the introduction of the disinfectant caps. Potential bloodstream infections were monitored using the Systemic Inflammatory Response Syndrome (SIRS) Criteria, and pan cultures were ordered if SIRS was suspected. In the case of inconclusive culture results, the CL was removed, and the catheter tip was cultured. Patients testing positive for bloodstream infections were treated and the CLABSI incidence was recorded.

Results from this study showed a statistically significant ($p < 0.04$) decrease in CLABSI rate, from 2.23 ± 0.39 to 1.07 ± 0.29 events per 1,000 central line days, after the introduction of the disinfectant caps. CLABSI rates also declined in the hospital's most critical patients, with a statistically significant ($p < 0.04$) drop in incidents in the coronary care unit (CCU) by 52% and a not statistically significant ($p < 0.11$) decrease in the medical intensive care unit (MICU) by 79%. These findings supported the growing evidence that alcohol-impregnated disinfectant caps may be used to help prevent CLABSI. The researchers recommended all facilities consider using

these disinfectant caps to keep CLABSI rates below the national benchmark. Some limitations of this study were that it was conducted at a single institution and the sample size was small. Additionally, the facility made other changes prior to the intervention, such as using the surgical team for CL placement and increasing nursing education regarding appropriate CL dressing changes, which could have played a role in reducing CLABSI risk. Besides these limitations, the study remained free from bias; the manufacturer of the disinfection caps was not involved in the study and the authors reported no conflicts of interest.

Voor In 't Holt et al. (2017) offered Level 5 evidence for this review with their systematic review and meta-analysis of quasi-experimental studies to compare the effect of alcohol-impregnated disinfectant caps and manual disinfection methods on the incidence of CLABSI. The researchers identified 1,537 potentially relevant articles using the following databases: Embase, Medline, Ovid, Web-of-science, CINAHL, EBSCO, Cochrane Library, PubMed, and Google Scholar. After duplicate exclusion, 953 articles remained for title/abstract screening, 18 articles were read full-text, and nine quasi-experimental studies were ultimately selected for inclusion in the review. Individual study quality was determined using the Downs and Black scoring system, finding the methodological quality of three studies to be low, four moderate, and two high. Six reviewers were responsible for extracting and checking the data. All studies compared the incidence of CLABSI per 1,000 catheter days before and after the introduction of disinfectant caps among inpatient adults with CLs on a variety of units and in different countries.

Ultimately, this study found the use of antiseptic barrier caps to be effective in reducing CLABSI, with evidence revealing a 59% risk reduction of the incidence of CLABSIs per 1,000 catheter-days compared to manual disinfection. As a result, the authors recommended adding

alcohol-impregnated disinfectant caps to central-line maintenance bundles to reduce patients' risk of CLABSI. Some limitations are the low quality of several studies, the low number of studies included, and the heterogeneity of the studies (as patient populations varied widely). The authors attempted to correct this heterogeneity by using a random effects model rather than a fixed effects model when analyzing the data, but the results should be interpreted in the context of the included studies. For future systematic reviews, the authors recommended inclusion of randomized controlled trials (RCTs), as these studies are less prone to bias.

Lastly, Wright et al. (2013) provided Level 3 evidence with their prospective, quasi-experimental study involving all inpatient adults with CLs in a four-hospital, university-affiliated health system. This study had three phases—baseline, intervention, baseline—to assess the efficacy of alcohol-impregnated disinfection caps on CLs to "(1) prevent or reduce bacterial colonization of the intraluminal space and (2) prevent bacterial CLABSI" (p. 33-4). This review will focus on the results related to the second outcome measure, CLABSI rates. Phase 1 of the study assessed baseline CLABSI rates among the four facilities, with standard disinfection practices being to *scrub the hub* with an alcohol disinfectant wipe prior to access (p. 34). Phase 2 involved the implementation of disinfectant caps on all CLs while not in-use, and Phase 3 removed the intervention in order to return to baseline practice. Throughout all three phases, CLABSI occurrences were assessed using National Healthcare Safety Network (NHSN) criteria and rates per 1,000 line-days were calculated using the facilities' electronic medical records.

This study found that CLABSI rates declined with the use of disinfectant caps and returned nearly to baseline after the intervention was removed. CLABSI rates per 1,000 line days before the intervention were 1.45, which decreased to 0.74 with the addition of the disinfectant caps, and rose back to 1.31 upon the intervention's removal. This evidence indicated that the use

of alcohol-impregnated disinfectant caps on CLs may be effective in reducing patients' risk of CLABSI. For this reason, the authors recommended the inclusion of disinfectant caps as part of standard CL maintenance protocols. One limitation of this study was that any lack of staff adherence to appropriate cap use could bias the study's findings "toward the null hypothesis of no effect" (p. 37). To compensate for this limitation, the facilities' infection prevention teams performed regular CL audits to monitor cap use and encourage proper staff adherence. The authors of this study reported no conflicts of interest.

Evidence Synthesis

In conclusion, the evidence appraised in this review suggests that using alcohol-impregnated disinfectant caps on inpatient adults' unused central lines can lead to an overall decrease in CLABSI rates within this population. The previously discussed studies all found a significant reduction in CLABSI rates when comparing the use of alcohol-impregnated disinfectant caps to manual disinfection methods (e.g., *scrubbing the hub*) or standard/non-antiseptic cap use. These antiseptic caps appear to prevent infection most effectively by providing continuous, passive disinfection of the catheter hub until removal, reducing the likelihood of bacteria entering the bloodstream. While the evidence from this review strongly supports the use of alcohol-impregnated barrier caps to reduce patient risk of CLABSI, it is important to recognize how study type, level of evidence, and limitations may affect the validity and applicability of these findings. A recommendation for future reviews is to include more RCTs (level 2 evidence) and systematic reviews and meta-analyses of RCTs (level 1 evidence) to provide evidence that will best support this cause-and-effect relationship.

Project Implications

With evidence supporting the benefit of alcohol-impregnated disinfectant caps in reducing patient risk for CLABSI, a quality improvement (QI) project related to the use of these caps in the ICU was appropriate to help this microsystem maintain their CLABSI rates as low as possible. While SwabCap® alcohol-impregnated disinfectant caps were already being used in this ICU, CL maintenance data showed room for improvement regarding adherence to proper capping protocol. For instance, weekly audits showed <100% of CLs being appropriately capped while not in-use which, as the evidence would indicate, may leave these patients at higher risk of CLABSI. It was important to work on increasing adherence to 100% in order to optimize patient outcomes. This QI project aimed to help this ICU maintain their current CLABSI rate of 0.00 through the end of the year 2022 by improving appropriate cap use on the unit. This project also intended to empower nurses by encouraging them to participate in evidence-based practice changes to minimize or prevent patient harm.

Rationale

Conceptual Framework

The Model for Improvement.

The Model for Improvement, developed by Associates in Process Improvement, is used as a framework used to accelerate improvement. This model has three parts: setting aims, establishing measures, and selecting possible interventions. These interventions are then systematically tested through Plan-Do-Study-Act (PDSA) cycles, in which a change is developed (Plan) and implemented (Do), the results are observed (Study), and future initiatives are based on what was learned (Act) (Institute for Healthcare Improvement [IHI], 2022). The PDSA framework was used in this quality improvement project to develop and test an intervention that

encouraged staff to consistently utilize alcohol-impregnated disinfectant caps on CLs while not in-use for continuous infusions in order to reduce the risk for CLABSI on the unit. During the Plan stage, current-state data was collected through weekly IP audits. Staff nurses were also surveyed to assess the reasons this aspect of the protocol was not being consistently followed, and an intervention was developed to address this main barrier. The Do stage involved implementation of the intervention, the Study stage involved collection and evaluation of CL maintenance data from weekly IP audits, and the Act stage involved analyzing outcomes to produce recommendations for subsequent PDSA cycles.

The Quality-Caring Model.

Created by Duffy & Hoskins (2003), the Quality-Caring Model can be used to explore factors that motivate nurses to make change and their willingness to apply evidence-based practice interventions. This theoretical framework can guide quality improvement activities by using evidence to show how suggested changes benefit patients, as many nurses are driven by their desire to prevent patient harm. Since this QI project relied on ICU nurses consistently participating in this improvement project, the Quality-Caring model was used to help ensure that this change was successfully made in the nurses' current practice. Specifically, framing this intervention to empower the ICU nurses by giving them means to reduce patients' risk of infection encouraged acceptance of a change that promoted patient safety.

Global Aim

The global aim of this QI project was to reduce the risk of CLABSI, allowing the ICU to maintain a CLABSI rate below the national benchmark and achieve zero CLABSI in 2022.

Specific Aim

The specific aim of this QI project was to improve adherence to CL protocol—specifically, to increase the use of alcohol-impregnated disinfectant caps (i.e., orange caps) on central lines not in-use from <100% to 100% by July 1, 2022.

Methods

Context

The microsystem for this quality improvement project was an 18-bed adult (ages 18+) Intensive Care Unit (ICU) within a 220-bed, level-II trauma center located in New England. A 5P's assessment of this clinical microsystem was conducted to guide the development of this project by identifying weaknesses in operation and possible areas for quality improvement. This assessment was important in highlighting the contextual elements relevant to this QI project.

Purpose

The ICU at this facility exists to offer specialized inpatient medical care for critically ill patients in order to support a patient's vital functioning, prevent worsening physiological damage, and avoid mortality. The ICU team provides support both for the patient and the family through education, interdisciplinary collaboration, individualized and compassionate care, ethical/honest practice, research, and continuous engagement in quality improvement efforts.

Patients

This ICU sees critically ill patients, many of whom have experienced a major surgery, an accident or trauma, a chronic or terminal condition, or a serious infection. The unit also admits patients who need closer monitoring than can be provided on a general unit. Length of stay in the ICU can vary from 24 hours up to several weeks before transfer to a step-down unit for less-

intensive care. This population is more at risk for CLABSI due to their critical condition and vulnerable state of health.

The unit is usually at maximum capacity, with 5,678 inpatient days logged in 2021 (American Hospital Directory, 2022). According to Leapfrog Group (2021), this facility had a total of 1,658 ICU admissions in 2021, with the patient census reflecting roughly 15-18 patients present in the unit each day, 35 per week, and 138 per month. This unit generally sees three admissions and discharges per day, with an average length of stay of 5.2 days in January 2022 (internal data). Overall, this facility has a four out of five star rating, ranking above the national average in timely/effective care, infections, and preventative care/screening (Medicare, 2022).

Professionals

The unit has 37 full-time nurses, led by the Nurse Manager and Nurse Director. These professionals, in addition to the unit's licensed nursing assistants (LNAs) and Infection Prevention (IP) team, work together to directly and indirectly prevent CLABSI. The unit also staffs many floating nurses, per-diem nurses, and traveling nurses based on the day-to-day staffing needs. All these professionals were stakeholders in this QI project.

Processes

The unit's nurses and Licensed Nursing Assistants (LNAs) collaborate to provide direct care for patients, including CL maintenance and patient hygiene to reduce infection risk. Both nurses and LNAs also share the responsibility of stocking supplies in patient rooms. The IP team monitors infection rates and mortality to identify unsafe practices and promote quality improvement initiatives. For example, this team performs weekly audits to check the unit's adherence to central line (CL) maintenance protocols. Data gathered during these audits revealed

a lack of adherence to appropriate use of alcohol-impregnated disinfectant caps on patients' central line ports while not in-use, a criteria intended to help prevent CLABSI.

Patterns

This audit data revealed cap use in February to May of 2021 to be 100% use in February, 90% in March, 85% in April, and 87% in May (Appendix A). In the recent ICU CL audits beginning March 2022, cap use has been 78% in March and 80% in April (Appendix D). According to evidence previously synthesized, with <100% cap use, these patients may be at higher risk of acquiring a CLABSI.

A tick-and-tally survey to determine the main reason these caps were not being used 100% of the time was created based on the Fishbone diagram regarding orange cap use (Appendix F). When surveyed using this method, 19 ICU staff nurses cited the following reasons for not consistently using orange caps: 1.) 68% because the orange caps were not stocked/available on the unit, 2.) 84% because orange caps were not conveniently located in patients' rooms, 3.) 47% because they forgot to place the orange cap, 4.) 16% because they did not know that orange cap use was part of CL protocol. 100% of nurses surveyed were aware that the use of orange caps on CLs can reduce the patient's risk for CLABSI. According to this survey, the main reason for lack of adherence to this protocol (cited by 84%) was that the caps were not always conveniently located to use after accessing a patient's CL.

These caps come in small blue SwabCap® bags containing 10 orange caps which can be found in the stockroom; due to COVID restrictions, more than one bag is not supposed to be stocked in each patients' room at a time, making it difficult to keep these caps consistently and conveniently located for use. When the caps are present in patient rooms, they are often kept in the drawers of the medication cart, out of sight until needed. Because the caps cannot be easily

seen from outside the room while in the drawers, they are often not noticed or replaced in a timely manner. These circumstances, along with the information gathered in the audits and survey, were considered in the development of a quality improvement initiative to address the barrier of convenience/location of caps in order to increase adherence to this protocol and reduce patients' risk of CLABSI.

Cost-Benefit Analysis

This problem was important to address because CLABSI treatment can cost a hospital an average of $48,108 per episode and may prevent insurance reimbursement for healthcare costs related to treatment (AHRQ, 2017). Implementing an intervention to reduce barriers to proper orange cap use may help reduce patents' risk of CLABSI, saving the hospital money by preventing these dangerous and costly infections from occurring. This intervention did not result in any additional cost to the facility or microsystem since the caps were already being used, so stocking these caps was already accounted for in the unit's budget. Personal costs were negligible and included only the printer paper and ink required for six pamphlets hung throughout the ICU.

It is also important to note that once bags and caps enter the patient's room, they are unable to be cleaned/used for another patient due to COVID restrictions, resulting in the waste of any bags and caps leftover after discharge/transfer. However, implementing the intervention under these circumstances did not create additional costs since one bag at a time was already meant to be stocked in patient rooms. Since the intervention only addressed bag location within the room, the amount of waste did not increase. Additionally, by placing the bag in a highly visible location (thus encouraging as-needed replacement to avoid accidental overstocking), this

intervention intended to help ensure only one bag was present in each patient's room at a time, preventing excessive waste.

Intervention

To improve consistent orange cap use, staff were encouraged to hang one cap bag on each patient's IV pole so the caps would be conveniently located for use after line access. When the last cap in the bag was used, the nurses were instructed to throw the bag away and replace it with a new bag from the stockroom. Due to the bag's bright blue color and conspicuous location, it was easily noticed if the bag was missing, prompting a nurse or LNA to replace it. This intervention intended to ensure the caps were always conveniently located both in each patient's room and in plain sight.

Stakeholders in this intervention again included the staff nurses and LNAs, the Nurse Manager and Director, and the IP team. The intervention idea was introduced to the unit's staff nurses and LNAs during two change-of-shift huddles and verbal agreement for participation was confirmed. The quality-caring model was emphasized during these meetings to encourage buy-in, first by sharing the evidence supporting disinfectant cap use to reducing CLABSI and then by discussing how improvement in this aspect of practice could help protect patients. A similar meeting was held with the Nurse Manager, Director, and IP team who also verbally offered their support. The unit leaders agreed to help ensure the cap bags were on each room's IV pole during their daily interactions on the unit, notifying the patient's nurse or LNA (both are responsible for ensuring that these caps are in the room) to restock these bags if they were missing. Six pamphlets were printed and hung in highly visible areas (i.e., break room door, break room table, white board, time clock, nurses station, and utility room door) which outlined the project intervention and goals, and reminded staff to participate. The Nurse Director also sent out a

reminder email to all staff regarding the change plan in an attempt to improve staff's awareness of the project and encourage participation. Lastly, the IP team confirmed continuation of their weekly audits and agreed to reach out to the patients' nurses or LNA if the bag was missing. These stakeholders' buy-in was critical to keep the intervention consistent on the unit.

Study of the Intervention

Weekly ICU audits with the IP team continued to provide data regarding CL maintenance protocol adherence (specifically, appropriate orange cap use on CLs that are not currently in-use for continuous infusions) in order to assess the efficacy of the intervention. During these audits, presence of the cap bag on the patient's IV pole was checked, helping to monitor whether staff were properly participating in the change plan. If audit data showed that the intervention was consistent on the unit (i.e., each patient has a cap bag present on their IV pole) and appropriate CL capping had improved, reaching 100%, a positive effect relationship could have been claimed. While the month allotted for this intervention may not have been enough to see immediate effects on the unit's CLABSI rates, the IP team and ICU administration will continue to monitor the unit for such infections in order to assess efficacy long-term.

Measures

During IP's weekly audits, all CLs not currently in-use for continuous infusions were checked for orange caps. The success of this project was gauged by assessing post-intervention audit data to identify whether appropriate cap use on ICU CLs reached 100%. Each of these audits also included a check to verify whether the cap bag was present on the patient's IV pole, helping to solidify a cause-and-effect relationship. Methods employed for assessing accuracy and completeness of these audits included a daily virtual meeting between ICU leadership and IP to verify which patients had CLs to ensure all were evaluated during the audit, and by using a

checklist to standardize protocol adherence criteria. These audits also had interrater reliability since they were generally performed during the same days and times each week by the same IP team members.

Analysis

Following the implementation of the intervention, weekly IP CL audits continued for the month of June 2022 to assess for any changes in cap use and to monitor the consistency of intervention's presence on the unit. Descriptive statistical analysis of the categorical data—including presence of the cap bag in each CL patients' room as well as the frequency and percentage of CLs appropriately capped each week—was provided via scatter plot to visualize outcomes and identify trends (Appendix B & C). The immediate process measure was percentage of CLs appropriately capped each week while not in-use for continuous infusions. The specific outcome goal was to reach 100% of lines appropriately capped each week after the start of the intervention. The expectation was to see cap bags present on all patient IV poles with a consequent increase in appropriate cap use from <100% to 100% after project initiation. Ultimately, the global outcome measure, or indirect effect of the intervention, was the unit's CLABSI rate for 2022, another data point that tracked by the IP team.

Ethical Considerations

No ethical concerns were identified prior to the implementation of this project. Patients with CLs gave verbal consent to the weekly IP audits, and this data on the use of the alcohol-impregnated SwabCap® was collected as part of the weekly audit. Additionally, since disinfectant cap use is an evidence-based practice and was already in-place as part of a protocol in this microsystem, no additional risks were introduced by this project. This proposal was reviewed by the UNH Department of Nursing Quality Review Committee, and a QI

determination letter was granted, confirming that this project was intended for quality improvement and not research. No conflicts of interest were identified for this project.

Results

Results

This QI initiative aimed to improve the appropriate use of alcohol-impregnated disinfectant caps on CLs that are not in-use for continuous infusions from <100% to 100% in order to maintain an ICU CLABSI rate of zero in 2022. Due to their critical health condition, the patient population in this microsystem is more vulnerable to infections like CLABSI; therefore, this project was designed to minimize patient risk and improve safety.

Initial Steps

Initial steps of the implementation phase began with meeting stakeholders to discuss project goals and propose a course of action. An in-person meeting was arranged with ICU leadership (the Nurse Director and Nurse Manager) to request support and to discuss their role in the project. During this meeting, these leaders verbally confirmed their involvement, promising to ensure the presence of the cap bags on each room's IV pole during their daily interactions on the unit and notifying the patient's nurse or LNA to restock these bags if they were missing. The Infection Prevention team was also contacted via email to confirm continuation of the weekly CL audits and to request the inclusion of this project's outcome measures (appropriate orange cap use and the presence of the cap bag on the patient's IV pole) in their data collection. These individuals also verbally agreed to assist with encouraging staff participation during the audits, reminding the nurses and LNAs to replace the cap bag if missing, to help keep the intervention consistent on the unit.

The next step involved introducing the project to the unit's staff nurses and LNAs during 0700 change-of-shift huddles on June 27 and June 31, 2022. The need for staff participation (i.e., ensuring that each of their CL patients always had a disinfectant cap bag on their IV pole) was explained and all staff verbally agreed to participate. In order to reach the staff members not present at those two meetings, the Nurse Director also sent out an email to all staff regarding the practice change to improve awareness of the project and encourage participation. Lastly, six pamphlets were printed and hung in highly visible areas (i.e., break room door, break room table, whiteboard, time clock, nurses' station, and utility room door) which outlined the project intervention and goals, and reminded staff to hang the cap bags on their CL patients' IV poles.

Data was collected with IP for two weeks following intervention implementation to assess patterns and determine the need for further staff/leadership engagement. Since intervention participation was low at this two-week mark, additional meetings with leadership and staff were organized to provide reminders about the project and to reinforce the need for staff/leadership participation. Data was then collected for three additional weeks.

Process Details

After the implementation of the intervention on May 27, 2022, quantitative data was collected during weekly CL audits, including the percentage of CLs appropriately capped and the percentage of CL patients with the cap bag present on their IV pole. The weekly capping percentages for these audits ranged from 60% to 100% and revealed a slight downward overall trend in capping protocol adherence (Appendix C). Audit data during the week of June 2 and June 9, 2022, revealed (respectively) 75% and 100% of CLs appropriately capped with 40% and 67% of cap bags present on these patients' IV poles (Appendix C). Since the intervention consistency was far below 100% at this time, the additional meetings with leadership and staff

were coordinated. The first audit following this engagement reinforcement revealed an improvement in intervention consistency, showing 100% of cap bags present with 71% of lines appropriately capped. However, capping results once again trended downward in subsequent weeks. The following audits revealed 80% capping adherence for the week of June 23, with intervention presence at an all-time low of 20%, and 60% capping adherence with 83% of cap bags present for the week of June 30 (Appendix C).

Overall, appropriate CL capping for the month of June 2022 averaged 75%, a decrease from the 78% recorded in March and 80% in April (Appendix D). This data revealed continuation of the negative trend in adherence to capping protocols seen pre-intervention (Appendix B). Despite the continued downward trend, the percentage of cap bags present on CL patients' IV poles (i.e., intervention consistency) appeared to be trending up (Appendix C). Ultimately, the project goal of 100% appropriate cap use after intervention implementation was not met. Despite the apparent decline in appropriate capping, the microsystem did not experience any hospital acquired CLABSI events throughout the project timeline, achieving this project's global aim of zero CLABSI occurrences to date in 2022.

Contextual Elements

Buy-in from the ICU healthcare team—including the Nurse Director, Nurse Manager, IP Team, staff nurses, and LNAs—was essential to keeping this intervention consistent on the unit. In the first two audits after implementation, presence of the intervention on the unit was less than 100% (40% the week of June 2nd and 67% the week of June 9th), indicating a lack of staff and leadership participation (Appendix C). This data revealed a need for further staff/leadership engagement to increase consistency of the intervention on the unit. Without intervention

consistency, any correlation between this practice change and capping protocol adherence could not be justified.

Possible causes of low engagement included forgetfulness or competing priorities within the leadership team, limiting their time and energy to continue daily monitoring of the intervention. For staff, the employment of traveling and per diem nurses could have affected staff awareness of the unit's participation and team members' consequent roles in this project. Attempts to resolve these issues included meeting again with leadership to restate the need for their daily involvement in maintaining intervention consistency. Staff involvement was then reinforced by providing reminders during two staff zoom meetings (one at 0730 and again at 1400) on June 15. The following audit on June 16 reflected improved participation, perhaps as a result of these reinforcement efforts, with the presence of cap bags rising to 100% and 71% capping observed. However, participation dropped again soon after, with only 20% of cap bags present during the June 23 audit, and 83% the week of June 30 (Appendix C).

Observed Associations

Overall, capping adherence averaged 75% in June 2022. The specific aim of this project (to reach 100% of CLs appropriately capped) was not met and the percentage of CLs appropriately capped in June 2022 was lower when compared to the two months prior to the start of the intervention (Appendix D).

Throughout the implementation phase of this project, only 69% of all CL patients audited were recorded as having the cap bag present on their IV pole. With less than 100% consistency of the intervention on the unit, it is difficult to provide substantial evidence that changes in capping protocol adherence may have resulted from this project's intervention. While general trends showed a decrease in capping adherence along with an increase in intervention

consistency, the weekly data suggests a possible positive association between the two, showing the percentage of CLs that were appropriately capped *with* the bag present on the IV pole (56%) to be slightly higher than those that were appropriately capped but did *not* have the bag present on the IV pole (44%) (Appendix E).

Unintended Consequences

Despite the negative trend in quantitative data, the staff response to the change was overwhelmingly positive. According to unit manager this project widely increased staff awareness of capping protocols: "I see [the caps on CLs] more now than I ever have since I have started here [in the ICU]." Staff even began hanging cap bags in all their patient rooms, not just those with CLs. One staff nurse was quoted saying "[hanging the cap bag on patients' IV poles] has become like a standard around here now," increasing availability and convenience of the caps for use on all IV lines, not just central lines. Another staff nurse stated that he and several of his coworkers felt that the intervention made cap access more convenient. Both statements imply that this project may have been helpful in overcoming the "lack of convenient access to caps in patients' rooms" (cited earlier by staff as the main barrier to capping adherence), despite the data indicating otherwise.

Missing Data

For this project, data was collected weekly, and no audits were missed. However, all trends observed in this project were based on only five days of post-intervention audit data. For future projects, daily auditing—rather than weekly—may be beneficial to gain a more thorough picture of patterns and trends. The recommendation is to continue encouraging the intervention on the unit and collecting data throughout the rest of 2022 to see if the capping practices begin improving over time, once the presence of the intervention is more consistent/closer to 100%.

Discussion

Summary

The specific aim of this project was to improve the appropriate use of alcohol-impregnated disinfectant caps on CLs that are not in-use for continuous infusions from <100% to 100%. The global aim of this project was to help the ICU microsystem maintain a CLABSI rate of zero in 2022. When conducting this initial PDSA cycle, the 5P's Assessment (Plan) revealed a quality gap regarding staff adherence to CL capping protocols as well as a barrier in cap accessibility that may have contributed to this issue. This information was used to develop an intervention (i.e., hanging disinfectant cap bags on patients' IV poles) to address this perceived process barrier and improve capping protocol adherence by staff. The change was implemented (Do) after gaining stakeholder buy-in among leadership, staff, and Infection Prevention using the Quality Caring Model to empower team members and encourage participation.

Overall, results (Study) revealed that this project did not meet its specific aim of 100% appropriate cap use by July 1, 2022, with capping adherence averaging 75% for the month of June 2022. The inconsistency of the intervention on the unit, with only 69% of CL patients audited having the cap bag present on their IV pole, may have contributed to this lack of improvement in capping adherence. While this project's specific aim was not accomplished, the global aim of maintaining zero CLABSI in the microsystem was achieved to date in 2022.

While capping adherence appeared to trend downward after the intervention implementation, weekly data suggested a possible positive correlation between hanging the cap bag on the patient's IV pole and appropriate presence of the cap on the patient's CL (Appendix E). Additionally, positive responses from staff and leadership regarding the intervention indicated that this change may have helped to make access to caps more convenient.

A strength of this project included participation of knowledgeable/experienced leadership and staff who were dedicated to patient safety and supportive of the quality improvement process. These individuals were already aware of risk factors/preventative measures for CLABSI and acknowledged the benefits of evidence-based practice changes. Another strength was that the intervention was generalizable to all staff on the unit, regardless of experience or skill, allowing staff nurses, leadership, and LNAs alike to participate in the initiative. Lastly, the unit encouraged cohesive interdisciplinary teamwork via daily zoom meetings with ICU leaders and the IP team, facilitating communication and offering support throughout the project.

Interpretation

Association Between Intervention and Outcome

The intervention for this project was developed based on input from staff regarding barriers to CL capping protocol adherence, with the expectation being an increase to 100% appropriate capping once the barrier was addressed. Ultimately, the outcome patterns did not support the expected association between intervention and improved capping adherence; rather, quantitative data revealed a downward trend in appropriate capping. Responses from stakeholders, however, appeared to support the benefit of this intervention in overcoming perceived barriers to accessibility.

Comparison of Results and Influence of Context

The outcome resulting from this intervention varied from expected findings supported by literature. Research by Hendrich et al. (2008) suggests that easing nurse workload via "relatively minor physical changes within a unit (such as distribution points of supplies or medications)," should reduce physical design limitations and promote protocol/process adherence. Development of the project intervention relied on this idea, since hanging the cap bag on patients' IV pole was

intended to address the issue of inconvenient cap access originally identified by staff. While responses from leadership and staff indicate that this change was helpful in mitigating the barrier, data collected did not support a positive association.

Ultimately, the anticipated outcome of this project (to see 100% of CLs appropriately capped by July 1, 2022) was not observed, and data instead demonstrated a decrease in appropriate capping compared to the two months prior to implementation. This decrease may be attributed to competing priorities on the unit among both leadership and staff, leading to inconsistent participation in the intervention. Since these team members' engagement was crucial to the success of the project, the outcome could reflect reduced stakeholder participation and engagement. This downward trend may also be party attributed to the infrequent collection of data which limited the information from which to identify patterns and draw conclusions.

Project Impact

This QI project provided an opportunity for staff empowerment, encouraging team members to apply evidence-based knowledge into their practice in order to minimize/prevent patient harm. Despite the negative trend in quantitative data, staff response to this change was overwhelmingly positive. Several staff nurses indicated that the intervention helped address the barrier of convenient cap access and, according to unit manager, this project may have also reinforced staff awareness of capping protocols. Overall, this project supported a culture of teamwork and quality improvement within the microsystem, encouraged communication and collaboration between leadership and staff, and emphasized patient care.

Cost-Benefit Analysis

The estimated total cost of this quality improvement project was $0 since the cap bags were already included in the microsystem's budget and staff engagement did not require the

purchasing of materials. Moreover, since there were zero CLABSI occurrences during the project timeline, the microsystem avoided costs associated with this infection which can amount to around $48,018 per event, in addition to lack of insurance reimbursement for any healthcare costs related to treatment (AHRQ, 2017). Therefore, the hospital ultimately saved money since these infections did not occur. Additionally, the highly visible placement of the cap bags encouraged as-needed replacement to avoid accidental overstocking which may have prevented unnecessary waste.

Limitations

There were several limitations to this QI project that disrupt the generalizability of the findings and should be considered in future project design/implementation. A main limitation included communication gaps between project leaders and staff. The large microsystem size and staffing of travelers, floaters, and per-diem nurses made it difficult to communicate effectively with everyone to ensure understanding of roles/responsibilities and to gain 100% participation. Additionally, the presence of these traveling/floating/per-diem team members resulted in many staff who may not have been aware of the protocols or change initiatives. Continued staff engagement tactics, including staff-wide emails and presentations at staff meetings, were used throughout the project to try and address this limitation.

Competing priorities for both leadership and staff may also have resulted in inconsistencies in monitoring and participating in the intervention, as indicated by the <100% intervention presence and capping adherence revealed by the audits. Staffing shortages, bed shortages, and other management responsibilities, for instance, might have preoccupied leadership, leaving them little time to monitor for the cap bags on patients' IV poles. Similarly, the high acuity of the unit likely presented many opportunities for staff nurses and LNAs to get

distracted, preventing them from consistently following up with bag placement/replacement. To try and address this limitation, regular meetings with leadership and staff were scheduled to communicate needs and reinforce participation.

Lastly, the infrequency of IP audits, occurring only once a week throughout the month of June, limited the amount of data available for analysis. If this initiative is continued and further PDSA cycles completed, leadership and IP may get a more accurate picture of trends from several months of daily, rather than weekly, audits. Besides these limitations, the study remained free from any other issues such as bias or confounding.

Conclusions

This QI project was useful within the unit, empowering both leadership and frontline staff to participate in evidence-based practice change and achieving the global aim of zero CLABSI events to date. Even though the specific aim was not met, the project was positively received by all team members, with several nurses verbalizing that the intervention was beneficial in addressing lack of convenient cap access. The project may have also helped raise staff awareness of the unit's capping protocols and best-practice CL maintenance.

According to leadership and IP, the intervention is expected to continue in the microsystem through the end of 2022 and will hopefully demonstrate improvements in capping adherence over time. In order to produce sustainable change in the unit, the intervention will need to occur consistently; long-term success will depend on the unit staff's participation and leadership involvement to ensure that this practice change is being observed. If this project shows positive results toward the specific and global aims by the end of 2022, this intervention could be utilized in other departments within the organization (e.g., Emergency Department, Oncology, Medical-Surgical, etc.) to improve capping adherence for all patients with CLs.

Implications for practice include continuing to promote consistent CL capping using alcohol-impregnated disinfectant caps, since evidence supports the benefit of this practice in preventing CLABSI. Additionally, stocking patient rooms should be delegated to LNAs or housekeeping, rather than nurses, because this task may not be a priority for nurses in a high acuity setting like the ICU, and therefore may be frequently overlooked. Delegating this task to unlicensed personnel may help to address the issue of competing priorities that might have reduced nurse participation. Lastly, daily leadership rounds should be emphasized to ensure cap bags are up and remind nurses daily of their CL capping responsibilities, since weekly rounds with IP did not appear to be sufficient.

In conclusion of this project's first PDSA cycle, further study is required to evaluate the staff's qualitative response that suggests this project was helpful in overcoming the barrier of convenient cap access, since the quantitative data does not support an associated improvement. It is recommended to resurvey the staff to identify strengths/weaknesses of this intervention, and to explore if other barriers may have contributed to the decrease in protocol adherence observed throughout the project. This information can then be used to develop and modify the intervention for the next PDSA cycle. Further quality improvement processes are essential to cement this evidence-based practice change and prevent CL capping protocol adherence from continuing to trend downward.

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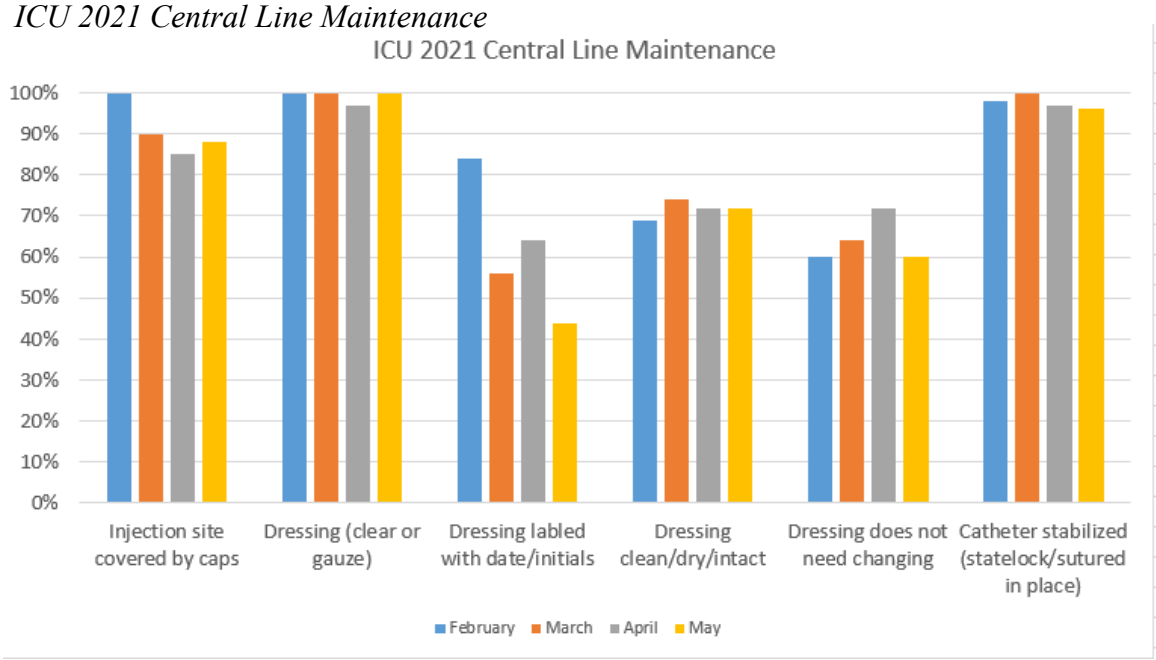
Appendices

Appendix A

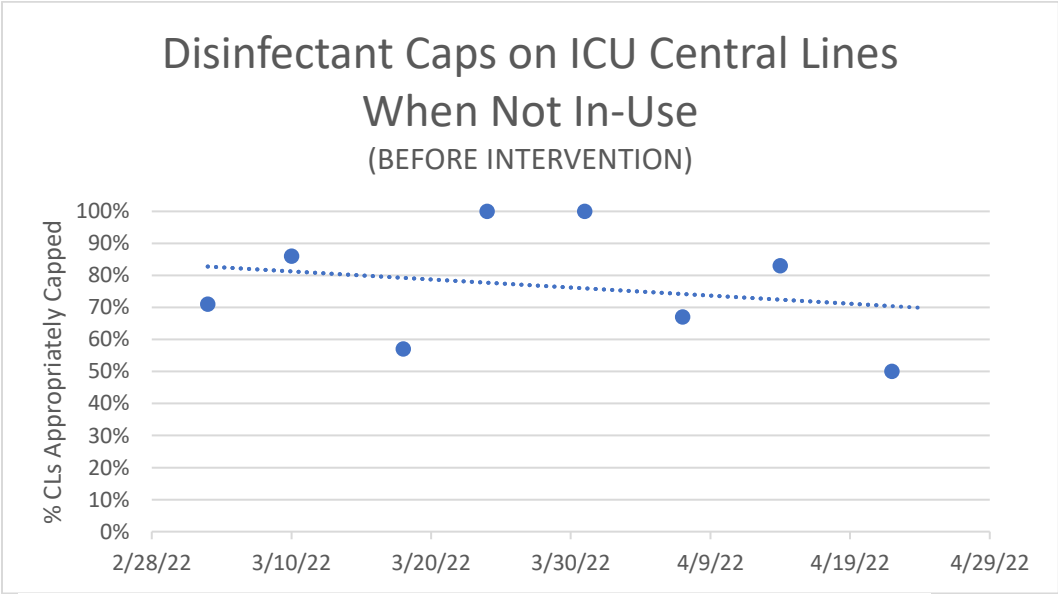
ICU 2021 Central Line Maintenance



Note. Central Line Maintenance in ICU for 2021

Appendix B

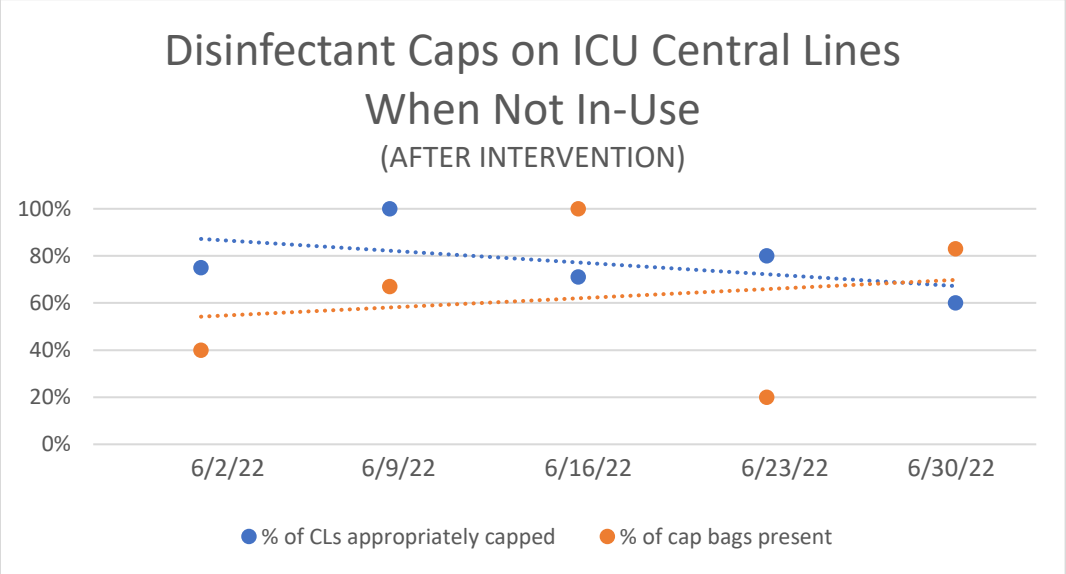
Disinfectant Caps on ICU Central Lines When Not In-Use (Before Intervention)



Note. Weekly ICU CL Capping Audit Data: Pre-Intervention

Appendix C

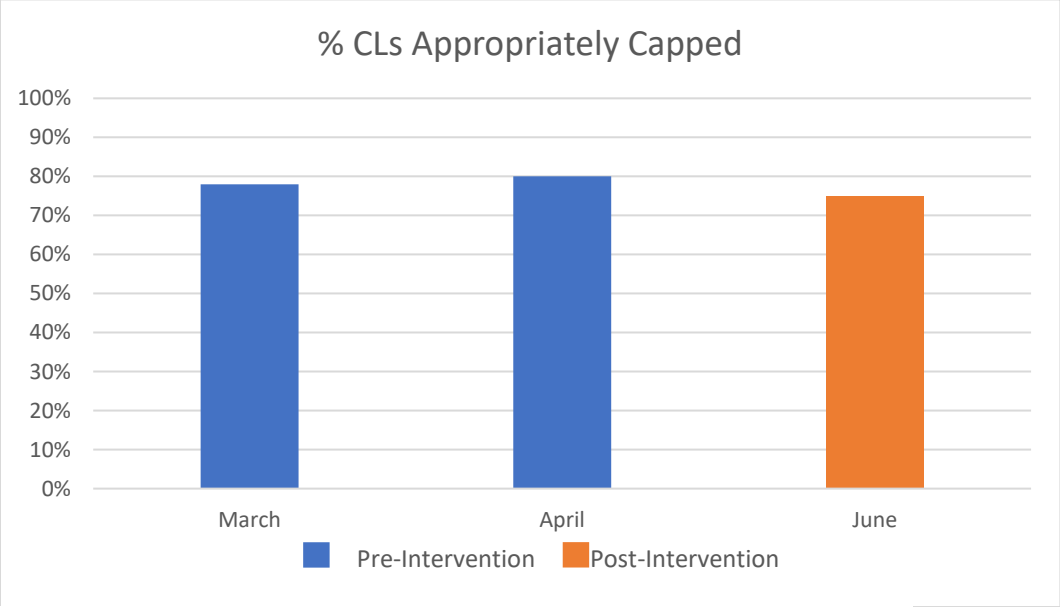
Disinfectant Caps on ICU Central Lines When Not In-Use (After Intervention)



Note. Weekly ICU CL Capping Audit Data: Post-Intervention

Appendix D

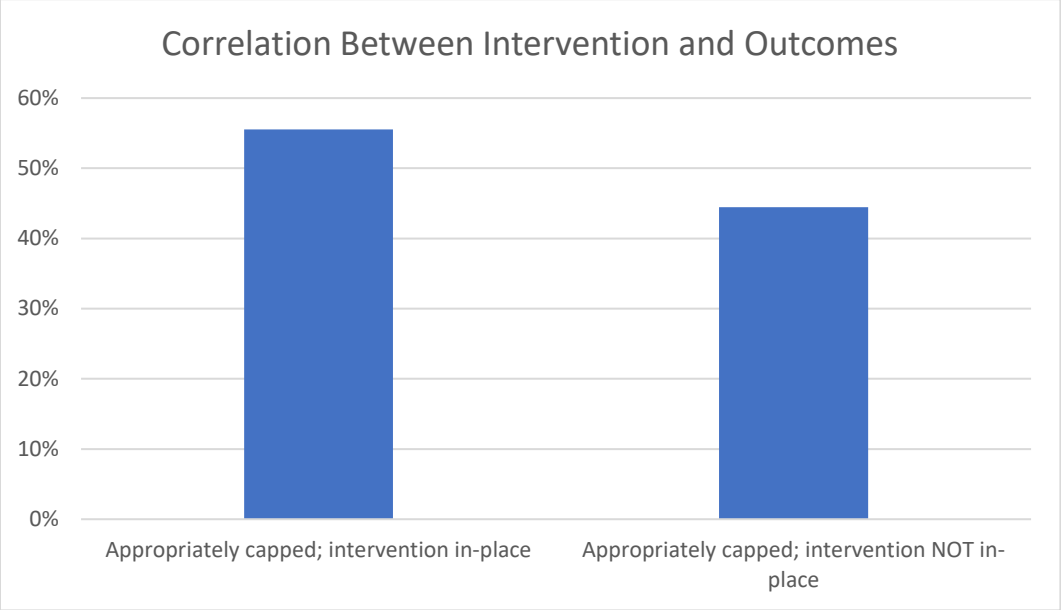
Percentage of Central Lines Appropriately Capped by Month



Note. Central Line Capping in ICU 2022

Appendix E

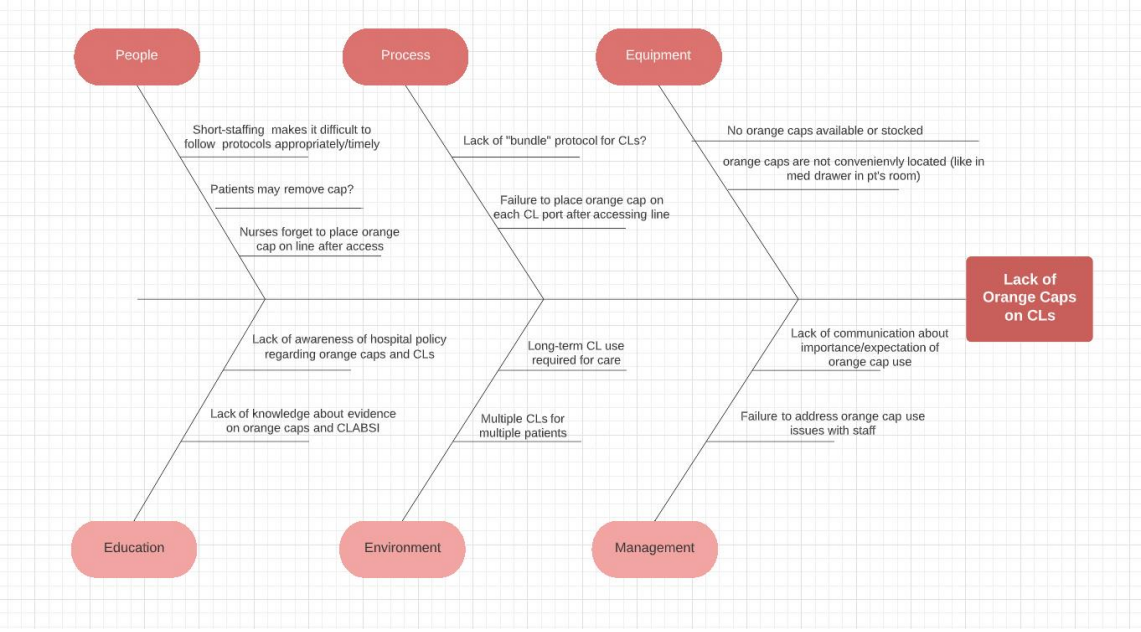
Correlation Between Intervention and Outcomes



Note. Correlation Between Intervention and Outcomes in ICU July 2022

Appendix F

Potential Barriers to Appropriate Orange Cap Use on CLs



Note. Fishbone Diagram: Orange Cap Use on CLs