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# A Quality Improvement Project to Improve Weight-Based Dosing of Cefazolin in the Perioperative Setting Among Patients Undergoing Knee Arthroplasty

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## Abstract

Surgical site infections (SSIs) continue to be a problem that affect the healthcare system not only on a national level, but on a local level as well. Adequate weight-based prophylactic antibiotic dosing is imperative in prevention of surgical site infections. Cefazolin is the most prevalent perioperative antibiotic administered. According to current guidelines, patients weighing greater than or equal to 120 kilograms (kg) should receive three grams of cefazolin. This project is a quality improvement project using the Plan-Do-Study-Act model for creation and dissemination of an original educational video on antibiotic stewardship and implementation of an electronic medical record (EMR) intervention for patients undergoing knee arthroplasty. Based on chart-reviewed data, it was determined that there is decreased compliance with current antibiotic dosing guidelines regarding both prescribing and administration. Evidence-based interventions included a web-based educational video discussing the institution's current perioperative antibiotic prophylaxis guidelines; additionally, an embedded hyperlink was created in the EMR in both the anesthesia record and Epic ordering screen to offer an easy access reference to both the ordering provider and administering provider. Pre- and post-implementation data were analyzed. Post-implementation data did not reveal increased compliance with prescribing and administration of cefazolin in patients undergoing knee arthroplasty.



## Keywords

Total Knee Arthroplasty, Obesity, Cefazolin, Ancef, Surgical Site Infection


## Disciplines

Nursing

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## Abstract

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# A Quality Improvement Project to Improve Weight-Based Dosing of Cefazolin in the Perioperative Setting Among Patients Undergoing Knee Arthroplasty

Surgical site infections (SSIs) continue to be a problem that affect the healthcare system not only on a national level, but on a local level as well. SSIs contribute to hospital acquired infections (HAI's) that incur unnecessary costs and increase patient morbidity and mortality. Per the 2018 National and State HAI Progress Report, there were 1,786, 276 Surgical Care Improvement Project (SCIP) procedures completed amongst 3,322 acute care hospitals nationally (CDC, 2018). SCIP is a series of protocols that standardize practices to reduce the risk of surgical infections. It was created in 2006 by the Centers for Disease Control and Prevention (CDC) and Centers for Medicare and Medicaid Services (CMS) in order to target complications that account for a substantial portion of preventable morbidity as well as cost. In 2018, there were 15,291 SSIs reported to the National Healthcare Safety Network (NHSN) (CDC, 2018). Currently in 2,111 acute care hospitals across the nation, any knee arthroplasty procedure and/or SSIs occurring in this surgical population are required to be reported to the NHSN. The latest data from 2018 shows that 553,112 knee arthroplasties were performed in the United States with 2,090 SSIs observed (CDC, 2018).

SSIs account for almost a quarter of all infections, and Hites et al. (2016) suggest that SSIs are the most frequent healthcare-associated infections. Regarding inpatient surgeries, SSIs occur in 2% to 5% of patients, leading to 160,000 to 300,000 SSIs in the United States each year (Berríos-Torres, Umscheid, & Bratzler, 2017). SSIs can increase hospital length of stay by an average of seven days (Bratzler, 2005). Associated costs of SSIs can range from $400 for a superficial infection to upward of $300,000 for organ/space SSIs (Najjar, 2015). As the number of surgical procedures continues to rise in the United States (Berríos-Torres et al., 2017), so do

health care expenditures associated with SSIs which is estimated to be between $3.5 and $10 billion dollars annually (Anderson et al., 2014). To mitigate the prevelenace, proper antibiotic administration reduced SSIs in several patient groups (Jones, 2014).

Obesity has become a major global burden on healthcare. The rate of obesity over the last 30-plus years across that world has increased from 29.8% to 38% for males, and 28.8% to 36.9% in females (Ng, Fleming & Robinson et al., 2014). This has affected the United States as well. The CDC reports that 42.4% of the U.S. population (139 million) were obese in 2018 (2020). The annual medical cost of obesity in 2008 was $147 billion dollars (CDC, 2019). Obesity also contributes to medical ailments that affect surgical populations such as certain cancers, osteoarthritis, coronary heart disease, gallbladder disease and type 2 diabetes (CDC, 2019). Higher prevalence of such adverse health outcomes, in turn, cause obese patients to undergo more surgeries than non-obese patients (Hussain et al., 2019). With obese patients having more surgeries and not receiving the appropriate dose of prophylactic antibiotics such as cefazolin, their chance of developing SSIs is theoretically increased. As anesthesia providers, Certified Registered Nurse Anesthetists (CRNAs) play a pivotal role in the process of decreasing SSIs, most notably in the obese surgical patients who have known drug-altering body habitus.

Antibiotic adherence is crucial for preventing SSIs. Patients that weigh greater than or equal to 120 kg require special attention prior to antibiotic administration. Current recommendations from the American Society of Health-System Pharmacists (2013) state that any patients whose weight is greater than or equal to 120 kg should receive three-grams of cefazolin for surgical site infection prophylaxis (compared to those weighing less than 120 kg who receive two-grams) (Bratzler et al., 2013). This recommendation was also published by the Infectious Diseases Society of America (IDSA) in 2013 (Hites et al., 2016) and the American

College of Obstetricians and Gynecologists (ACOG) (Kram et al., 2010). An advisory statement published from the National Surgical Infection Prevention Project recommends consideration of a patient's weight and body mass index (BMI) to ensure dosing adequacy (Stitely et al., 2013). These guidelines hold validity and importance in clinical practice based on the well-established scientific underpinnings of the pharmacokinetic and dynamic properties of the drug. In addition, cefazolin is cost-effective and has a beneficial safety profile. This further justifies the recommendation to administer three grams of cefazolin to prevent the incidence of SSIs in an increased risk patient population (Braztler et al., 2013).

Knee arthroplasty is not only a common surgery in the United States but also at Cooper University Hospital in New Jersey. From June 1, 2018 through July 31, 2019, Cooper hospital performed 275 knee arthroplasties. Out of those 275 patients, 17 patients weighed 120 kg or more and were administered cefazolin as their primary prophylactic antibiotic. Out of these 17 patients, seven (41%) did not receive the correct recommended dose. It was also determined that 69% of the 17 patients did not have the correct dose of prophylactic antibiotics prescribed preoperatively (Figure 1). This is a concerning finding and clearly indicates that an intervention is warranted regarding appropriate cefazolin prescribing and administration during knee arthroplasty patients who are greater than 120 kg.

Appropriate prescribing and administration of weight-based cefazolin in perioperative knee arthroplasty patients is an ongoing concern for both anesthesia providers and obese surgical patients. Improving knowledge of antibiotic pharmacodynamics related to this specific patient population while making established weight-based dosing protocols more visible and user-friendly has the potential to improve patient outcomes and decrease SSIs. There have been several studies published supporting the use of the electronic medical record (EMR) to improve

prophylactic antibiotic administration. O'Reilly (2006), Kanter (2006), Nair (2010), and Wax (2007) have all demonstrated an improvement in the administration of prophylactic preoperative antibiotics when utilizing EMR-based administration interventions. In a retrospective study evaluating the efficiency of a reference text to the EMR, Van Sise, Chappelle, and Figueroa (2012) report improvements to the proper selection of preoperative antibiotics for cesarean deliveries in a labor and delivery unit. It was determined that this reference helped to prompt physicians to prescribe the recommended dose and antibiotic (Van Sise et al., 2012). None of these studies specifically evaluated knee arthroplasty patients, cefazolin administration, or a specific surgical line. They all focus on the utilization of an EMR intervention to improve either antibiotic prescribing or administration practices in the surgical setting. In this context, this quality improvement project aims to assess the effect of two interventions on the compliance of prescribing and administration of cefazolin. These interventions include a web-based educational video discussing the institution's current perioperative antibiotic prophylaxis guidelines and an embedded hyperlink to the guideline which offers an easy access reference to both prescribing and administering providers.

## Methods

### Setting and Current Practice

Cooper University Hospital is an academic, level I trauma center in southeast New Jersey. Cooper has 635 registered beds, and in 2018 it had 28,716 patient admissions (Cooper, 2018). Currently, there are over 7,000 employees of Cooper hospital. As an academic center, Cooper accommodates 318 full-time equivalents (FTE) for interns and residents, along with having multiple care specialty nurse residencies. In terms of surgery, there are 36 operating rooms at Cooper Hospital. In those rooms staff performed 3,766 surgeries in 2018 (Cooper,

2018). The department of anesthesiology includes 43 anesthesiologists, 17 residents, and 69 full-time nurse anesthetists.

Cefazolin was chosen compared to other prophylactic antibiotics in knee arthroplasty patients due to its use as standard antibiotic prophylaxis. Currently at Cooper, antibiotic orders are placed by the surgical team prior to surgery. A patient's weight is often taken at their pre-operative visit with the surgeon in their office; however, this visit can be done 30-60 days prior to surgery. A more recent measure of the patient's weight is obtained during intake by preoperative staff, often after their antibiotic is ordered. Due to the unknown variable of weight, the anesthesia provider is often presented with an order that does not reflect the correct weight-based dose. The burden of proper antibiotic administration is then placed onto the anesthesia provider during the intraoperative period, increasing their workload and likelihood for error due to the task-saturated time period of administration (post induction of anesthesia, pre surgical incision). Antibiotics given outside the realm of anesthesia are prescribed by a provider and cross-referenced by pharmacy prior to administration by the nurse, a process that can take time to complete. The proper administration of antibiotics in anesthesia is imperative and must be completed in a very short time period at the discretion of the anesthesia provider. This can lead to discrepancies between the prescribed dose and the administered dose.

**Interventions**

Our intervention is two-fold and is based on the Plan-Do-Study-Act model (PDSA) for process improvement (Moen, n.d.). The Cooper Epic team is responsible for overseeing the hospital's EMR program Epic. During discussions with the team, it was determined that the anesthesia and ordering providers should have a more readily available means of accessing the institution's recently updated perioperative antibiotic guidelines. This intervention involved the

establishment of an embedded hyperlink in both the anesthesia record and Epic ordering screen of the EMR. The goal of this intervention was to offer an easy reference to the guideline for both the prescribing and administering providers. In addition, an educational video was created for the anesthesia team (Kline, Moore, & Vickers, 2020). This was accomplished through an original video created using Vyond (GoAnimate Inc., 2020), an online animation software program. The video was written and created by the team, along with voiceover. In the video, the importance of correct weight-based dosing of cefazolin and its national and local level implications were conveyed to the viewer. The video also included the prototype example of the EMR embedded hyperlink. The video was uploaded to a private account on YouTube in which only those who utilized the video link could access the video. Upon the date of project implementation, this video was disseminated at a weekly anesthesia departmental meeting, as well as being sent via e-mail to all anesthesia providers.

**Study of the Intervention**

In order to measure the effect of the intervention, two chart reviews were conducted to collect data on correct weight-based dosing of cefazolin. A pre-implementation retrospective chart review from June 2018 through July 2019 was completed. The data were limited to these months prior to meeting with Cooper staff to prevent bias regarding staff discussion of the project. Following implementation, a chart review was completed from September 2020 through October 2020. The post-implementation data set was used to determine if any changes occurred that corrected antibiotic prescribing practices and administration. To support our PDSA model for improvement, we analyzed data at the end of every week to monitor for any changes in perioperative cefazolin prescribing and administration that occurred. Knee arthroplasty patients at Cooper Hospital who were given cefazolin perioperatively and were greater than or equal to

120 kg were included in the study. Patients who weighed less than 120 kg were excluded as well as patients who received a different antibiotic during their intraoperative course.

**Measures**

Pre- and post-implementation chart reviews were chosen to compare intervention effect. The main outcome was compliance of correct weight-based prescribing and administration of cefazolin in patients greater than or equal to 120 kg. Due to the time period of implementation and the limitations of this project, which include only analysis of data from one surgical service, aggregate data were measured to better see a positive outcome. If a positive outcome was found with prescribing and administrative practices of cefazolin, this may be evidence attributable to the intervention, but a more robust study design is needed to prove causality.

Compliance with viewing the educational video was a secondary outcome. At the beginning of the implementation, this project was presented at a weekly anesthesia departmental meeting to ensure that the video was viewed in its entirety by the members of the anesthesia department. The video was also disseminated via email to all members of the anesthesia department for viewing. A follow-up email was sent four weeks after the initial email to help ensure adherence. Data were obtained on the number of times the video was viewed. Project costs were minimal, and the intervention was created to minimize disruptions in daily workflow to Cooper hospital staff and administration.

**Analysis**

Patient weight and antibiotic dosing were extracted through chart review of data entered by Cooper Hospital staff. Descriptive statistics were used to summarize the absolute frequency and percentage of antibiotic prescription and administration during pre- and post-intervention

periods. Data were collected, stored, and analyzed through Microsoft Excel. Due to limited and unequal sample sizes, inferential statistical analysis was not performed.

**Ethical Considerations**

Proper antibiotic prescribing and administration is necessary to prevent SSIs which can lead to poor patient, hospital, provider and system outcomes previously noted in the introduction. Our project identified a systems process that led to patients weighing greater than or equal to 120 kg not receiving the guideline cefazolin dose of three grams. All parameters of this project design have been clearly identified in order to prevent unethical data analysis and interpretation. Our project implementation aimed to inform and give the provider an easily accessible resource for set antibiotic guidelines and did not otherwise change administration practices.

**Ethics approval**

A project Institutional Review Board (IRB) application was submitted to both the University of Pennsylvania and Cooper University Hospital through their respective processes. Both institutions reviewed the project applications and deemed it process/quality improvement. The authors report no conflicts of interest and received no form of compensation for the completion of this study.

## Results

During the seven-week post-implementation data collection period, a total of 34 total knee arthroplasty patients were identified. Four of these patients weighed greater than or equal to 120 kg, meeting inclusion criteria for the QI project. Post-implementation descriptive analysis of the data revealed that out of the four total knee arthroplasty patients weighing greater than or equal to 120 kg, one patient was prescribed the correct dose of cefazolin and one patient was administered the correct dose. This resulted in a 75% noncompliance rate for both outcome

measures (Figure 1). When looking to our pre-implementation data set (n=17), we identified that 41% of patients undergoing TKA weighing greater than or equal to 120 kg did not receive the correct dose of cefazolin and 69% did not have the correct dose prescribed. Comparing our pre- and post- implementation data, compliance for both prescription and administration of cefazolin decreased after completion of our intervention.

Regarding anesthesia provider compliance with educational video viewing, a total of 50 views were tallied via YouTube analytics and 80 anesthesia providers were accounted for during the anesthesia department meeting. Unfortunately, this data is not specific. It does not account for the fact that YouTube video views might have occurred multiple times by the same provider, nor does it separate partial versus complete video views. To improve performance regarding our key measures, a follow-up email was sent out to the anesthesia department with the link to our educational video in hopes to reinforce learning and encourage viewing of the video throughout the entire anesthesia department.

## Discussion

### Summary

Subjectively, it has been our clinical experience that adequate prescribing and administration of cefazolin for the patient weighing greater than or equal to 120 kilograms is a challenge for a multitude of reasons in the interoperative period. Objectively, this is evident through both pre- and post-implementation data showing an inability for accurate prescribing and administration.

### Interpretation

Though the data revealed a 75% noncompliance with the prescription and administration of cefazolin in knee arthroplasty patients weighing greater than or equal to 120 kg, there were

many strengths identified in this project. First and foremost, we uncovered a problem that was not believed to be an issue within the institution. Drawn to this project by the buzzwords of "infection prevention", discussion with anesthesia colleagues at Cooper University Hospital unearthed a potential problem. Furthermore, a retrospective review of data revealed lack of compliance with proper prescription and administration of cefazolin in our target population. Perseverance and passion about this project, combined with collection of evidence to substantiate this problem transformed our project team into a group of multidisciplinary professionals working together to find a solution to this problem.

Through collaboration with our multidisciplinary team including members of the anesthesia team, infection prevention, pharmacy, information technology, and Epic specialists, numerous barriers to proper antibiotic dosing were identified along the continuum of care. Of note, as a result of root cause analysis of possible contributory factors for noncompliance with adequate dosing of cefazolin, inaccessibility of patient weights during preadmission testing visits were identified as a potential barrier. Consequently, an Epic upgrade was implemented at the beginning of August 2020 outside the scope of our project implementation, which made patient weights more readily visible to prescribing clinicians prior to admission of the patient to the hospital for surgery. This was initiated in hopes of solving one piece of this multi-faceted problem.

Despite the institution having a comprehensive and direct antibiotic guideline, it was not being properly accessed and utilized in clinical practice. Many providers were even unaware of the existence of this guideline. While it is possible that our educational video was not effective at educating the anesthesia providers on proper weight-based cefazolin dosing, we believe it brought attention to the guideline. The video also generated discussion amongst the department

regarding proper administration, as well as a downstream effect through other surgical lines regarding proper antibiotic administration. Based on the literature, our project team assumed there would be increased compliance with proper prescribing and administration of antibiotics. Previous studies have shown that EMR interventions along with staff education increase compliance with medication prescribing and administration at large (Kanter, 2006; Nair, 2010; O'Reilly, 2006; Van Sise, 2012; Wax, 2007). Our data did not show the positive change that was evident in our review of the literature. This is likely due to a host of limitations that were not seen in other published studies that we reviewed. We hypothesize that our outcomes are not truly reflective of the impact of our intervention due to a short data collection period and resulting small sample size. The project team was successful at overcoming challenges among multiple levels of the organization at not only recognition of compliance issues with cefazolin prescribing and administration, but identification of specific barriers throughout a patient's perioperative course.

**Limitations**

The major limitation of this project involved the presence of confounding factors that could have influenced study results and were unaccounted for. During the time of project implementation, the project institution shifted surgical resources to address an increasing COVID-19 population and ceased non-emergent surgeries such as total knee arthroplasties. Orthopedic procedures began again in late Spring 2020, but total numbers were slow to meet pre-implementation levels. This, along with a short project implementation period, limited the number of potentially eligible surgical cases, thus leading to a small post-implementation sample size. The COVID-19 pandemic also presented unique challenges to anesthesia providers with task overload and education saturation. In this context, it is possible that providers were less

likely to watch the educational materials and engage with the content. The choice of a single surgical procedure further limited our ability to assess changes in antibiotic prescription and administration in the context of patients weighting greater than or equal to 120kg. We believe the aforementioned factors negatively impacted the effectiveness of our project implementation. Due to the backlog of Epic projects and modifications from COVID-19, the hyperlink in the anesthesia record was not developed in time for the project implementation.

Data collection regarding the number of educational video views was also a major limitation of this study. The video was watched during Cooper's anesthesia department meeting and attendance was taken by simply counting the number of anesthesia providers in attendance of the virtual meeting. Additionally, the video was sent out to the anesthesia department via email with a link to the video on YouTube. YouTube metrics merely present a number of video views and do not account for the same provider watching it numerous times or partial views of the video. Likely, there was overlap between providers who watched the video during the meeting and also watched the video on YouTube. Dissemination of the video via these two mediums was done to increase viewability amongst our stakeholders. The department presentation was limited to an online platform versus a normal in-person presentation. This prevented an accurate attendance count of the departmental meeting along with preventing usual anesthesia provider dialogue and interaction, possibly hampering stakeholder buy-in.

**Conclusions**

This quality improvement project contributes to the body of evidence that adequate and appropriate cefazolin prescribing and administration is still a challenge; however, educational interventions to improve knowledge and provide awareness can help to promote practice change. Our unsuccessful short-term goals do not adequately reflect long term sustainability through

decreasing work-flow barriers by implementing technology-based interventions. Identifying challenges that prevented proper antibiotic prescribing and administration through communicating with multiple stakeholders is paramount for sustainability. Addressing practice issues with administration of medications now, specifically antibiotics, can have a long-term effect of antibiotic viability in addressing future surgical site infections. This quality improvement project exemplifies many of the challenges that occur in making effective practice changes to benefit patients and the healthcare systems in general. Our project has exposed a multifaceted problem which warrants a multifactorial solution extending beyond the scope of this endeavor. Future quality improvement projects seeking to address the issues of antibiotic prescription and administration among patients weighing greater than or equal to 120 kg should consider verifying and utilizing an EMR-based intervention. Additionally, including other surgical lines in data analysis along with collecting a larger post-implementation sample would allow for stronger inferential analysis.

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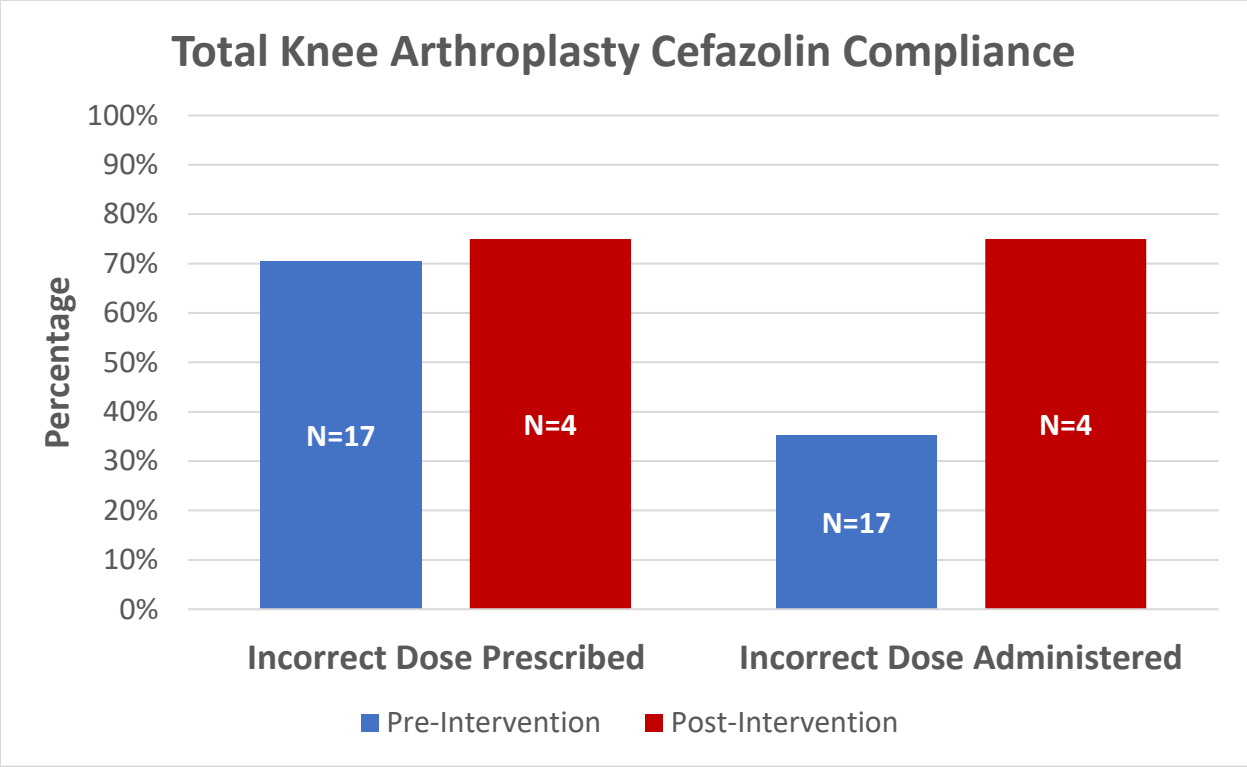


**Figure 1**

*Bar chart showing noncompliance of prescription and administration of cefazolin, both pre-implementation and post-implementation*