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Quality Improvement of the Extended Antibiotic Infusion Administration Process

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by

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Abstract

Dynamic issues associated with infection create unprecedented demands for quality healthcare improvements and modifications. Researchers found extended antibiotic infusions to be an effective treatment option with significant clinical benefits to patients and astounding cost savings. This scholarly project identified the emergence of several clinical issues threatening to undermine the intended patient responses to extended antibiotic infusion therapy in one large hospital system.

Problem: Unrecognized infusion delays and short infusion durations created the need for an educational pilot initiative to improve the administration process of piperacillin/tazobactam on one nursing unit.

Intervention: Nurses on the pilot unit received instruction regarding the pharmacodynamics of time-dependent antibiotics and the infusion management of dead space volumes. Random infusions were monitored post instruction for consistency and accuracy.

Results: Of the 73 nurses who were emailed a self-instruction module, a total of 30 (41%) nurses submitted an attestation for completing the instruction. Each nurse completing the instruction responded 100% correctly to all five post-test questions (150 questions/150 correct). Of the randomly observed post-instruction infusions, 17 of 29 pumps (59%) were programmed to infuse according to the instruction. Infusions programmed for 100% of the duration ordered increased from zero to 59% post instruction. The difference in minimum inhibitory concentration (MIC) pre and post instruction demonstrated a 72% improvement in the therapeutic duration delivery of piperacillin/tazobactam.

Conclusion: The educational intervention, designed to redefine the beginning of the extended antibiotic infusion, was recommended as a sustainable solution to this practice problem.

Keywords: extended antibiotic infusions, prolonged antibiotic infusions, piperacillin/tazobactam, stewardship, smart pump, dead space volume, infusion management, quality improvement

Acknowledgements

Words pale in comparison to the support and resources I have received from countless faculty, colleagues, family, and friends throughout this Doctorate of Nursing Practice project. Each and every contribution was priceless and wholeheartedly appreciated. From the beginning of the project as an empirical concept through its conclusion in publication, the acknowledgement granted my professional concern for improving patient care has been my motivation. At this time, I most gratefully recognize all the healthcare professionals who have participated in this project. Overall, this experience has reinforced my dedication and commitment to nursing and pride in my professional community. When improvement is needed, nurses can most definitely be trusted to achieve those outcomes.

Speaking out to create change within a large organization is never easy. The organization that I selected, however, is to be commended for its commitment to quality care provision. Employees from bedsides to boardrooms demonstrated a willingness to listen and to pursue clinical benefits for patients. In particular, the nurses and management staff of the Cardiovascular Surgical Intermediate Care Unit demonstrated the utmost professional integrity and skill. Completion of this DNP project would not have been possible without their expertise, devotion, and capacity for caring.

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SECTION I

Problem Recognition and Significance

Introduction

Healthcare continues to be transformed by medical advances and technology. Continuous research and advancements challenge healthcare professionals to keep up with ongoing changes. Dynamic issues associated with acuity and comorbidities, such as infection, create unprecedented demands for quality improvements and modifications. Prior to 2010, researchers found extended antibiotic infusions to be an effective treatment option with major cost savings (Droege, Van Fleet, & Mueller, 2016; Falagas, Tansarli, Ikawa, & Vardakas, 2013; Yost & Cappelletty, 2011). As global applications of extended antibiotic infusions spread rapidly to reduce healthcare costs, researchers realized significant clinical benefits and positive patient outcomes (Droege et al., 2016; Falagas et al., 2013; Heinrich et al., 2011; Maddox, DeBoer, & Hammerquist, 2014). Significant reductions in mortality rates and lengths of stay (LOS) began frequenting the literature as a direct result of extended antibiotic infusion therapy (Droege et al., 2016; Falagas et al., 2013; Heinrich et al., 2011; Lee, Liou, Yee, Quan, & Neldner, 2012; Maddox et al., 2014; Yost & Cappelletty, 2011; Yusuf, Spapen, & Pierard, 2014).

Clinical Scenario

Mr. Johnson was admitted to the hospital for diverticulitis and underwent a sigmoid colectomy for repair of a micro-perforation of the sigmoid colon. Routine postoperative management included the administration of an extended antibiotic infusion of piperacillin/tazobactam (Zosyn®) 3.375 grams intravenously in 50 milliliters (mL) of normal saline (NS) for a duration of four hours at a frequency of every eight hours. The

nurse assigned to care for Mr. Johnson on his first postoperative morning entered his room at 0700 and found his 0400 dose of Zosyn still infusing at the appropriate rate of 12.5 mL hourly. At 0800, the nurse completed the four-hour infusion as indicated on the electronic medication administration record (MAR), disconnected the tubing from the patient, and flushed the peripheral intravenous (IV) access with NS in accordance with protocol. The night nurse documented the administration of the medication at the time the Zosyn was hung according to the secondary intravenous infusion policy and the day nurse completed the extended infusion.

This scenario routinely occurs in the selected healthcare organization with supporting documentation that extended antibiotic infusion administration is flawless. Further investigation, however, reveals several variables with the potential to significantly undermine intended patient responses to this pharmacologic therapy. Variables include:

- primary and secondary infusion tubing preparation policies,
- total infusion tubing volumetric capacity (known as *dead space;* see Figure 1),
- primary line NS flush amounts and rates post-infusion to clear the line of drug,
- MAR documentation of the infusion start time with an automated stop time documentation exactly four hours following initiation,
- individual nursing judgment regarding completion of infusion begun by the previous nurse.

This scholarly project identifies the emergence of several clinical issues threatening to undermine the intended patient responses to extended antibiotic infusion therapy in one large hospital system.

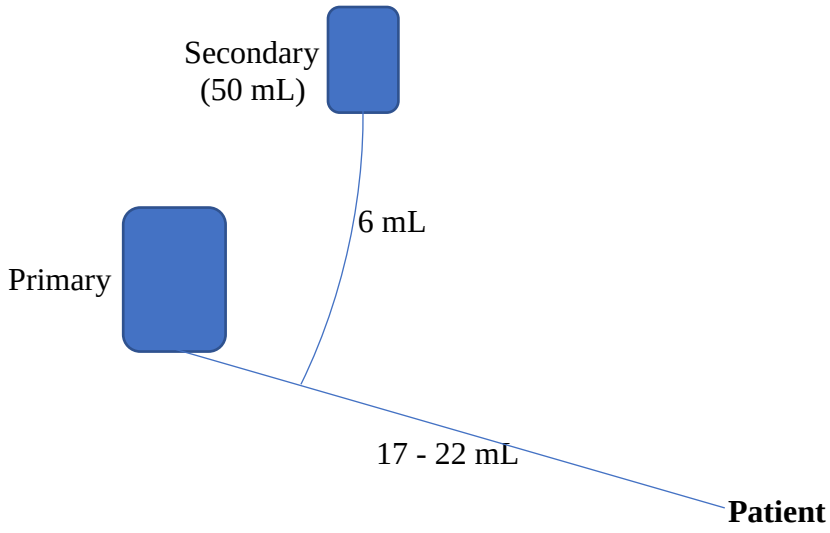


Figure 1. Basic Piperacillin/tazobactam Secondary Infusion Setup

Concepts and Definitions of Terms

Pharmacodynamics of Piperacillin/tazobactam

Piperacillin/tazobactam is a β-Lactam classified antibiotic with *time-dependent*, rather than concentration-dependent, pharmacodynamics. Time-dependent antibiotics have shorter half-lives and can only achieve optimal bacterial killing while being bacteria-bound for a specific duration of time (Deglin & Vallerand, 2015; Droege et al., 2016). Peak concentrations of time-dependent antibiotics have limited effect on bacterial killing. It is the duration of bacterial exposure to the time-dependent antibiotic that ultimately determines the extent of bacterial destruction. Minimum inhibitory concentration (MIC) refers to the least amount of antibiotic needed to kill at least 90% of a bacterial pathogen (Droege et al., 2016; Falagas et al., 2013). An antibiotic's MIC must be exceeded for the intended duration to sustain bacterial killing. MICs vary between 40% and 70% of dosing intervals for different antibiotics (Droege et al., 2016).

Physicians ordering a four-hour piperacillin/tazobactam infusion every eight hours are targeting 50% of the dosing interval to exceed the MIC. Four-hour piperacillin/tazobactam infusions every eight hours have been found to have the same clinical benefits for patients as continuous piperacillin/tazobactam infusions (Falagas et al., 2013). Antibiotic infusions administered too quickly result in shortened durations, thus minimizing bacterial killing. In addition to achieving optimal bacterial killing, a pathogen's MIC has been associated with the potential for inhibiting multi drug-resistant organisms (MDROs) (Droege et al., 2016; Falagas et al., 2013).

Stewardship

Extended antibiotic infusion therapy has been studied heavily this century in response to the escalation of antibiotic resistant bacterial strains and MDROs (Falagas et al., 2013; Fan et al., 2017). Last year, the Centers for Disease Control and Prevention (CDC) reported over two million antibiotic resistant cases resulted in approximately 23,000 deaths in the United States (CDC, 2017). MDROs are the result of inconsistent and ineffective antibiotic usage (CDC, 2017). Antibiotic *stewardship* refers to the deliberately organized inter-professional strategies to ensure optimal antibiotic use in combating infection (American Nurses Association [ANA]/CDC, 2017; CDC, 2017). Intravascular exposure of the pathogen to the antibiotic for an extended duration is intended to facilitate extended bacterial killing while suppressing the development of resistant bacterial mutations. Nurses play an integral role in the stewardship against MDROs in various healthcare settings (ANA/CDC, 2017; Droege et al, 2016; Manning, Pfeiffer, & Larson, 2016; Monsees, Goldman, & Popejoy, 2017; Morgan, 2017; Olans, Olans, & DeMaria, 2016). It is important for nurses to develop and maintain a current understanding of the pharmacodynamics and pharmacokinetics behind the best practice evidence supporting extended antibiotic infusions (ANA/CDC, 2017; Droege et al, 2016; Manning et al., 2016; Monsees et al., 2017; Morgan, 2017). The ANA and CDC collaborated to emphasize the need for nursing involvement in antibiotic stewardship to improve antibiotic use in healthcare settings (ANA/CDC, 2017). The CDC (2017) developed four core actions, including stewardship, to guide professionals in combating antibiotic resistance. The Joint Commission (2016) established a new standard for

medication management teams in hospitals as of January 1, 2017, specifically requiring antimicrobial stewardship action in controlling MDROs.

Dead Space

Dead space refers to the volumetric capacity of the intravenous infusion pathway a solution travels from exiting its original container until reaching the patient's intravascular space (Lam, Bhowmick, Gross, Vanschooneveld, & Weinstein, 2013). Dead space for the extended antibiotic infusion varies depending on the volumetric capacities of several infusion pathway setup options. Setups vary according to patient condition and therapy needs, available supplies, and individual nursing judgment. The basic setup (see Figure 1) dead space volume ranges from 21 to 28 mL, including possible extensions and catheters.

The amount of dead space is most significant when the infusion volume is small (less than 100 mL) and rates are slow (less than 20 mL/hour) (Alexander & Zomp, 2015). Dead space must be completely displaced by piperacillin/tazobactam before the medication arrives at the patient's intravascular space. Without this displacement, the slow rate of the extended piperacillin/tazobactam infusion (12.5 mL/hour) creates an infusion delay of approximately two hours. Likewise, when piperacillin/tazobactam completely exits its original container, the dead space remains filled with the medication. This dead space must be flushed by the primary solution at the same rate the medication is ordered because the medication is continuing to infuse (Callahan, 2015).

Backpriming

Backpriming refers to the retrograde filling of the secondary intravenous infusion pathway with primary solution. The purpose of backpriming is to displace residual

medication from the previous infusion with primary solution into the used medication bag which is then discarded. Medications, such as piperacillin/tazobactam, must be stored in the refrigerator or reconstituted just prior to infusion to maintain optimal pharmacodynamic effectiveness. Residual medication in the secondary dead space following an infusion has been at room temperature for several hours and is discarded through the backpriming process.

Infusion management requires nurses to decide whether or not to backprime prior to each secondary medication infusion. Backpriming to discard residual medication versus infusing the residual medication in the secondary infusion pathway is currently left to nursing judgment. The current nursing practice is generally to backprime for all secondary medication infusions and dedicate each tubing to its own medication for reuse for up to four days.

Background

Extended Antibiotic Infusions

The selected practice organization is a large private, nonprofit health care system in North Carolina that received Magnet recognition by the American Nurses Credentialing Center in 2015. Extended antibiotic infusions of piperacillin/tazobactam were added to the pharmacotherapy options at the selected organization in 2010 using smart pump infusion technology (S. Holt, lead pharmacist overseeing extended antibiotic infusions in the selected organization, personal communication, September 15, 2017). Piperacillin/tazobactam infusions formerly administered over 30 minutes at intervals of six hours began being administered over four hours at intervals of eight hours. The pharmacy-led implementation in 2010 was primarily introduced as a cost-saving benefit.

Both intermittent infusions currently remain in use as pharmacotherapy options in the selected organization.

Practice Problem

The administration of extended antibiotic infusions in this organization has encountered two nursing practice problems. These problems were initially identified through empirical data discovered over an extended period of direct involvement in the clinical setting. The first issue surrounds the inaccuracies of the nursing administration process of extended antibiotic infusions. The second issue involves the organizational system failure to recognize medication administration mishandling with potentially serious clinical and financial threats.

SECTION II

Needs Assessment

Organizational Gap Analysis

Best-practice evidence regarding extended antibiotic infusions is relatively recent in nursing literature and can be associated with a characteristic knowledge to action healthcare practice gap, as in this selected organization. This nursing practice gap is characteristic of the assimilation of new evidence and its integration into practice (Field, Booth, Ilott, & Gerrish, 2014). Based on nursing interviews summarized in Table 1, patients are currently receiving an uncertain amount of medication at a significantly reduced duration from that which was ordered.

Table 1.

Causes and Effects of Current Extended Infusion Administration

Administration action	Impact	Problem	Inaccuracies
20 – 60 mL flush amount following dose	Flush displacing residual med in infusion pathway;	Risks incomplete med dose +/or ↓ dose duration	Duration and documentation
12.5 -100 mL/hr flush rate following dose	↑rate causes ↓intended dose duration	Risks ↓ dose duration; inconsistency; uncertainty when shifts change	Duration and documentation
Smart pump alarm or MAR indicator for infusion completion?	Both indicators variable based on flush settings; MAR based on scanning the container, not the infusion beginning at the patient	Inconsistency; uncertainty when shifts change; inaccurate	Dose, duration, and documentation

Following the extended infusion period, flushing procedures used to clear residual drug volume in the tubing vary among nurses in the selected organization as outlined in Table 1. According to personal communication, nurses often speed up the volume to infuse rapidly, which negates the time-dependent pharmacodynamics needed for effective therapy. Current documentation validates that the nursing administration of extended antibiotic infusion is consistent and accurate. The assumption throughout the organization, based on this documentation, is that piperacillin/tazobactam is being administered consistently and accurately.

As illustrated in Table 1, nurses are administering inconsistent dosage durations. Nurses are administering inaccurate dosage durations. Nurses are, unintentionally, documenting inaccurate infusion administration. The “right dose”, “right time”, and “right documentation” professional standards for nurses are jeopardized by the current practice. In addition, the practice problem continues to be unrecognized and uncorrected.

Problem Statement

Integration of best-practice pharmacotherapy of extended piperacillin/tazobactam infusions has evolved inconsistently in the selected organization. The practice problems in the selected organization are: (1) the inaccurate nursing administration of extended antibiotic infusions and (2) the organizational system failure to recognize medication administration mishandling with potentially serious clinical and financial threats.

Scope of the Practice Problem

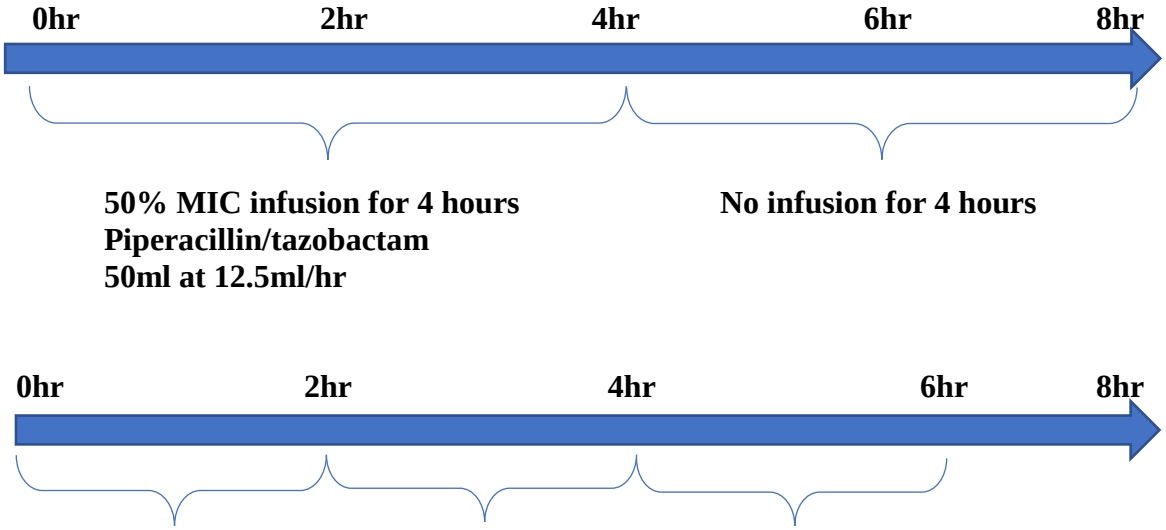
Current Practice

Extended piperacillin/tazobactam infusions are a frequently utilized pharmacotherapy at the selected organization for the treatment of both gram positive and

gram negative infections. Shannon Holt, lead pharmacist overseeing extended antibiotic infusions in the selected organization, reported piperacillin/tazobactam is the primary pharmacotherapy for gram negative infection (S. Holt, personal communication, September 15, 2017). Holt also reported no increases in either gram negative infection rates or drug-resistant strains since the pharmacy-led implementation of extended piperacillin/tazobactam infusions in 2010. Since the implementation, however, significant benefits of mortality and LOS reductions have predominated the literature. Mortality and LOS have become the primary indicators for extended antibiotic infusion therapy (Droege et al., 2016; Falagas et al., 2013; Heinrich et al., 2011; Maddox et al., 2014).

Piperacillin/tazobactam administered in extended dosages in the practice organization occurred multiple times daily on one clinical unit during direct observation periods. Associated practice problems can be attributed to knowledge deficits regarding the time-dependency of piperacillin/tazobactam and infusion dead space volumes. Nurses administering piperacillin/tazobactam infusions have limited policy guidance to manage infusion dead space volumes and their effects on infusion durations. Knowledge deficits and policy confusion regarding infusion volumes have resulted in loss of approximately 50% of time-dependent infusion therapy with each dose (see Figure 2). The ANA and CDC White Paper identified antibiotic-related practice problems as a threat to patient safety (ANA/CDC, 2017).

Intended infusion administration:



Duration problem with current infusion administration:

No medication reaches patient for approx. 2hrs but counted as infusion time due to current policy	**Med reaches patient and begins infusing at intended rate**	**Period left to nursing judgment with inconsistent actions**

Figure 2. Eight-hour Medication Frequency Timeline

Clinical Issues

- Current infusion policy allows varied interpretations of extended infusions.
- Nurses beginning infusion at the bag rather than the intravascular space due to dead space volume.
- Reliance of nurses on smart-pump technology capabilities.
- Absence of infusion volume capacity on infusion supplies packaging to inform nurses for decision-making.

- EPIC documentation of infusions beginning at false times.
- Potential variance of actual dosages patients receive with replacement of dead space volume following infusion.
- Assumptions of contributors to the infusion process are that nursing management of infusion volumes is accurate.

SECTION III

Review of Literature

Best-Practice Evidence

Antibiotic therapy has historically been guided by bacterial susceptibility to a certain antibiotic. MDROs to the most commonly used antibiotics has resulted in the emergence of alternative dosing strategies such as the extended antibiotic infusion (Droege et al., 2016; Falagas et al., 2013). Certain antibiotics, such as piperacillin/tazobactam, have proven in vitro to be most bactericidal when infused over an extended period, making them time-dependent antibiotics (Droege et al., 2016; Falagas et al., 2013; Fan et al., 2017; Lee et al., 2012). Minimal drug concentrations are needed to inhibit bacterial growth, but concentrations must remain constant for an extended duration to effectively destroy bacteria. Receiving the entire dose too quickly interrupts bacterial exposure to the minimal inhibitory concentration (MIC) required to prevent bacterial growth (Droege et al., 2016; Falagas et al., 2013; Fan et al., 2017). Therefore, although a bacterial pathogen may be susceptible to an antibiotic and the entire dose is administered, bacteria are given the opportunity to multiply between antibiotic doses. In a study of 5,000 patients with hospital associated pneumonia, Kim, Kuti, and Nicolau (2009) found that three-hour piperacillin/tazobactam infusions were not as effective as other beta-lactams; but all were more effective than 30-minute duration infusions. Administering time-dependent antibiotics too quickly has been associated with longer hospital stays and with greater mortality (Falagas et al., 2013; Stanford Health Care, 2015).

In a cohort study of 194 patients with pseudomonas infections, Lodise, Lomaestro, and Drusano (2007) were the first to associate significant mortality and length of stay benefits with extended piperacillin/tazobactam infusions. Falagas et al. (2013) shared a meta-analysis reviewing 14 studies of over 1,200 patients and their findings relating extended antibiotic infusions to clinical outcomes. Piperacillin/tazobactam effectiveness was consistently enhanced with extended infusion durations. Significantly decreased mortality rates and LOS were demonstrated. These findings continued to be corroborated by multiple researchers as extended infusions were integrated into global healthcare settings (Lee et al., 2012; Maddox et al., 2014; Schmees et al., 2016; Yost & Cappelletty, 2011; Yusuf et al., 2014).

Once piperacillin/tazobactam has been ordered as an extended infusion, it is critical that the infusion time begins when the antibiotic begins infusing into the patient's intravascular space. It is just as critical that the infusion continues slowly for the entire four-hour duration period. (Alexander & Zomp, 2015; Stanford Health Care, 2015). Alexander and Zomp (2015) reported up to 60% of the piperacillin/tazobactam dose can be lost to residual dead space volume.

Administration Evidence

A literature review revealed the emergence of both extended antibiotic infusion therapy and smart pump technology throughout many healthcare settings at approximately the same time, between 2010 and 2015. Other simultaneous rollouts, such as electronic patient record (EPR) enhancements, also emerged for many organizations within the same timeframe, as was the case at the selected organization. Smart pump usage in United States hospitals has increased from an estimated 44% in 2007 to more

than70% as of January 2018 (Pedersen & Gumpper, 2008; Institute for Safe Medication Practices [ISMP], 2018).

Smart pump technology advanced the intravenous infusion capability from counting drops to pre-programmed infusion libraries with safeguards against much of the human error associated with medication administration (Ohashi, Dalleur, Dykes, & Bates, 2014; ISMP, 2009; Reston, 2013). Potential solutions to the identified practice problems must involve implementation and evaluation to optimize the use of best technology practices. System inefficiencies associated with utilization of new technologies need quality improvement support that will enhance informatic growth and development (Ohashi et al., 2014; Trbovich, Cafazzo, & Easty, 2013).

Infusion delivery delay is not widely covered in the literature, but it has been recognized as a common cognitive task deficiency among nurses (Yui Tsang, 2015). Yui Tsang (2015), a pharmacist student, developed and implemented an interactive education simulation for identifying and teaching critical care nurses about infusion volume management. Heinrich et al. (2011) implemented a hospital-wide extended piperacillin-tazobactam infusion guideline in total replacement of the 30 minute option in an Illinois medical center in 2008 with positive results. Researchers felt the single extended infusion option promoted consistency of administration surrounding the protocol change and therefore, enhanced reliability of results. Trbovich, Pinkney, Cafazzo, and Easty (2010) examined nurse utilization of smart pump technology in relation to medication administration errors. Researcher recommendations cautioned against complacency, especially with secondary infusions. It was concluded that, although smart pumps

mitigated many nursing infusion errors, other potential errors regarding pump programming during each infusion took their place (Trbovich et al., 2010).

Lam et al. (2013) found that as much as 60% of the piperacillin/tazobactam 50 mL dose has been lost to residual tubing volumes. In studies of over 800 nurses, the ISMP (2018) found the most common type of smart pump errors were associated with secondary infusions. The reported errors demonstrated nurse confusion about secondary infusion doses and rates (ISMP, 2018).

Trbovich et al. (2013) evaluated the optimal use of smart pump technology safeguards in 29 hospitals in Ontario. These researchers identified that underutilization of potential safety features was common. It was concluded that accuracy of the medication process required collaborative monitoring of smart pump usage due to unpredictable and complex implementation variables (Trbovich et al., 2013). Kirkbride and Vermace (2011) also cautioned nurse managers against the unintentional consequences of protective technology. Maintenance of an accurate awareness of administration practices during extended antibiotic infusions throughout the organization will be key to success.

Extended piperacillin/tazobactam infusions are most commonly selected to target susceptible pathogens such as fluoroquinolone-resistant P*seudomonas aeruginosa*, *Klebsiella pneumoniae*, *Escherichia coli,* or carbapenem-resistant Enterobacteriaceae (CRE) (Droege et al., 2016). Extended piperacillin-tazobactam infusions have yielded benefits of significantly reduced lengths of hospital stays and mortality rates for patients (Buyle et al., 2013; Heinrich et al., 2011; Falagas et al., 2013; Lee et al., 2012; Lodise et

al., 2007; Maddox et al., 2014; Schmees et al., 2016; Yost & Cappelletti, 2011; Yusuf et al., 2014).

Literature Summary

A Literature Review Matrix outlines major details (see Appendix A). Overall, the evolution of evidence surrounding extended antibiotic infusion therapy demonstrates a transition from economical healthcare infusion benefits to clinical outcome benefits for patients experiencing infections. Cost benefit, the original incentive for extended infusion therapy, is now secondary to significant mortality and length of stay reductions.

Consistently competent administration of extended antibiotic infusions is fundamental to the achievement of successful patient outcomes the literature demonstrates. Direct observation and personal communication with frontline nursing staff and policy-makers corroborate knowledge deficits regarding best-practice pharmacotherapy. Compliance with best-practice evidence is critical to the achievement of similar clinical benefits for patients. Unaddressed infusion errors during time-dependent infusion therapy directly impact the success of clinical patient outcomes. Current extended infusion issues at the selected organization warrant further investigation with translation and application of best-practice solutions.

SECTION IV

Theoretical Framework

Swanson's Theory of Caring

Kristen Swanson's (1993) Theory of Caring provides the theoretical framework for this practice project to enhance extended antibiotic infusion administration accuracy and efficient dose delivery for clients experiencing infections. "Nursing is informed caring for the well-being of others" (Swanson, 1993, p. 352). Swanson's (1993) explanatory middle-range nursing theory defines "others" as individuals or groups, or issues that jeopardize well-being. The theory of caring outlines specific caring processes within the context of four phenomena common to nursing practice: persons or clients, health and well-being, environments, and nursing (Swanson, 1993). These phenomena are common to nursing practice, but not exclusive to nursing practice (Swanson, 1993). The unaddressed infusion issues during administration of extended antibiotic therapy in the selected organization constitute a nursing practice issue that influences client well-being.

The five caring processes are hierarchically structured beginning with "maintaining belief", the foundational values and beliefs guiding nurses to assist others through their specific situations (Swanson, 1993). This basic underlying foundation of beliefs inherent to nursing, through the actions of each nurse, initiates the relationship between the nurse and others toward some future outcome (Swanson, 1993). Nurses accompany others through their experiences or situations to provide therapeutic assistance (Swanson, 1991). The theory of caring identifies clinical nursing knowledge as the second caring process toward achieving planned outcomes (Swanson, 1993). What

nurses know and understand regarding specific client data determines the care that nurses will tailor to be most therapeutic (Field et al., 2014; Swanson, 1993). Holistic awareness and understanding of individual patient influences and needs guide nursing judgment and caring actions. Swanson further elaborates that knowing promotes scholarly nursing practice applications and translations (Swanson, 1993).

The remaining three caring processes, "being with, doing for, and enabling" (Swanson, 1993, p. 355), directly support the effectiveness of nursing care in promoting client well-being. Responsibility and accountability of nurses to others, including oneself, impacts individual perceptions of dignity and worth (Swanson, 1991; Swanson, 1993). Recipients of nursing care based on caring theory perceive protection and security from competent nursing skillsets (Swanson, 1991; Swanson, 1993). Recipients of nursing care (whether clients, issues, or nurses themselves) progress through personal experiences toward an intended result (Swanson, 1993).

Swanson's structured caring processes serve as the ideal organizational framework for planning and implementing a policy revision and quality improvement initiative to achieve optimal pharmacotherapy for clients (see Figure 3). The theory of caring provides praxis to guide all nursing relationships; those with clients, other nurses, other disciplines, and with oneself (Butts & Rich, 2015; Swanson, 1993). Because these dynamic inter-relationships continuously influence the implementation process, they require ongoing assessment and management (Field et al., 2014). Sustainable knowledge translation can be expected to withstand barriers to the change process through the use of implementation science strategies (Field et al., 2014). Implementing change within an organization can be mindfully facilitated through the use of Swanson's Theory of Caring

to translate knowledge of best-practice among nurses with the intention of enhancing client well-being (Swanson, 1993).

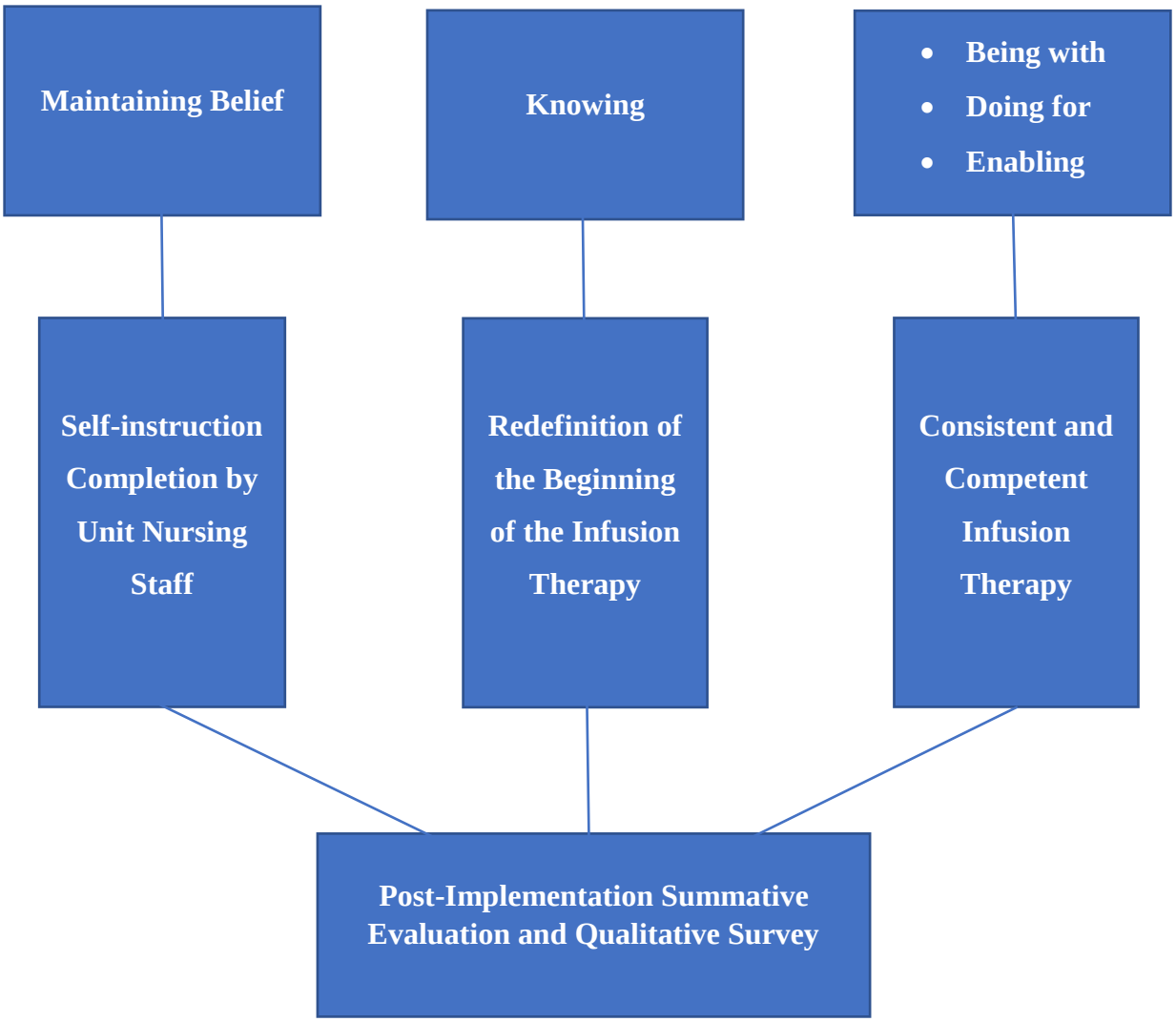


Figure 3. Conceptual/Theoretical/Empirical (CTE) Diagram Based on Swanson's Theory of Caring

SECTION V

Project Mission, Goals, and Objectives

Mission Statement

The purpose of this scholarly project was to improve extended antibiotic infusion administration of piperacillin/tazobactam therapy by teaching best practice strategies for consistent and compliant dose delivery needed by patients experiencing infections.

Goals

The anticipated goals for this scholarly project are:

- Recognition and application of best-practice pharmacotherapy guiding extended antibiotic infusion administration
- Recommendations for a system-wide self-instruction module for nurses
- Recommendations for a revision to the extended infusion administration policy.

Objectives

The objectives of this scholarly project are:

- Attestation to completion of a self-instruction module redefining extended antibiotic infusion administration by 100% of unit nurses
- Summative validation of understanding regarding the nursing administration of time-dependent antibiotics by 100% of unit nurses upon completion of the self-instruction module

- Self-reported increase in understanding of the nursing administration of time-dependent antibiotics by 100% of responding unit nurses upon completion of the self-instruction module
- Consistent and accurate delivery of four-hour intravascular antibiotic exposure by 100% of unit nurses upon completion of the self-instruction module as randomly monitored for two weeks.

SECTION VI

Project Design

Site and Population

The selected unit for implementation of this pilot project was a 41-bed cardiovascular surgical intermediate care unit with approximately 80 staff nurses. Employment on the unit ranges from one to 35 years. The majority of nurses have a Bachelor of Science in Nursing (BSN) level of education and many have achieved national medical-surgical certifications.

Table 2

Project Team Members

Team Members	Reasons for Selection
Kelly Thompson-Brazill	Selected Practice Partner; DNP with respected clinical expertise and organizational network
Megan Swink, Morning unit supervisor and tenured staff nurse	Selected Committee Member; knowledgeable of frontline staff practices on direct observation unit; respected, energetic, and proactive with clinical expertise and organizational network
Sandra VanScoy, Nurse manager and tenure on observation unit	Thirty-two years of tenure on direct observation unit; respected for availability, support, and expertise
Shannon Holt, Pharmacist	Responsible for management of antibiotic dosing in collaboration with Dr. Ingram, Infectious Disease Specialist; aggregates all data regarding extended antibiotic infusions
Dr. Chris Ingram	Infectious Disease Specialist
Dr. Eric Raasch	Pharmacy and Therapeutics Committee (P&T) Systemwide Chair

Facilitators

The selected organization consistently demonstrates numerous strengths, especially after receiving Magnet Recognition status. An organizational culture of striving for excellence in maintaining competitive quality health care outcomes for patients throughout the region is communicated within the hospital system as well as through community outreach and support. Organizational growth and development demonstrate the successful mission of improving health care provision through quality and compassion. Patients and families are positioned at the top of the hierarchal pyramid. Specific achievements validating this structure are displayed on each unit. Employees actively participate in decision-making through shared governance and committee integration of quality improvements.

Barriers

Three identified barriers to integration of best infusion practices contribute to the inaccurate administration of piperacillin/tazobactam extended infusions in the selected organization. The first barrier to overcome in implementing a solution is the knowledge deficit of the nursing staff associated with dead space volumes as well as the time-dependency dynamic of piperacillin/tazobactam. Training regarding extended antibiotic therapy was provided to nurses at the selected organization in 2010, but frontline staff nurses were taught there were no advantages to extended infusions beyond cost savings. Subsequent evidence discovered since then identified cost savings is a secondary benefit of the extended piperacillin/tazobactam infusions (Heinrich et al., 2011; Maddox et al., 2014; Droege et al., 2016). The primary advantage to extended therapy has become its clinical benefit to patients; that evidence is currently translating to the selected

organization and nursing practice (Buyle et al., 2013; Falagas et al., 2013; Yusuf et al., 2014). Education regarding time-dependency in antibiotic administration to nurses at the selected organization is critical to the implementation of accurate extended antibiotic infusions. Heinrich et al. (2011) demonstrated successful implementation of new guidelines in a structured educational training session for all involved professionals in a 500-bed Chicago hospital.

A second barrier to accurate extended antibiotic infusions is the absence of tubing volume capacity information for use by the frontline nursing staff when programming the infusions. Knowledge of the volume capacity of the infusion tubing is essential to accurately determining infusion beginning and end points (Alexander & Zomp, 2015; Lam et al., 2013). Failure to include this volume in the current infusion setup has resulted in a significant delivery delay in the selected organization. With current nursing practice, the antibiotic does not reach the patient until the third hour of the intended four-hour infusion.

The project manager discovered a third barrier to correcting the practice problem, more fragmentation throughout this organization than originally recognized. The selected organization is large and the dynamics of problem-solving are complicated by the ongoing daily challenges and complexities of managing multiple campuses. Communication is unexpectedly difficult given the quantity of responsible stakeholders and the magnitude of the practice problem. The magnitude of this practice problem adds an overwhelming element for stakeholders anticipating an equally complex solution. The planning period needed to develop the redefinition pilot project was extended by the fragmentation encountered. Going forward through the implementation and reporting of

results phases, this project manager more effectively managed the intra-organizational division of responsibilities to streamline efforts and outputs.

SWOT Analysis

Strengths, weaknesses, opportunities, and threats (SWOT) analysis of the practices, policies, and opportunities in the selected organization revealed a gap between actual and intended practice procedures as illustrated in Table 3. Internal and external strengths of the selected organization clearly exceed the internal and external weaknesses (see Table 3). The foundational climate of the selected organization is perceived as professional and valuing quality care both internally and throughout the community. Acknowledgement of the practice problem with various stakeholders has elicited concerned responses and participatory implementation toward a policy update as well as a quality improvement initiative.

Table 3

SWOT Analysis

	Positive	Negative
Internal	• Culture of striving for excellence in maintaining competitive quality health care outcomes for patients throughout the region • Patients and families are positioned at the top of the hierarchal pyramid • Specific achievements validating this structure are displayed on each unit • Employees involved in decision-making through shared governance and committee integration of quality improvements • Well-educated and skilled frontline nursing staff • Collaboration between pharmacy and physician professionals with nurses mutually respected throughout this organizational system culture • Adequate physical and fiscal resources	• Miscommunication of information in rollout • Absence of tubing volume capacity information for use by the frontline nursing staff when programming the infusions • Policy for secondary intravenous infusions allows variability in the administration • Ineffective ongoing monitoring of extended infusions • Persistent nosocomial pathogens
External	• Community outreach and support • Organizational system growth and development • Respected reputation nationally • Magnet recognition • Successful mission of improving health care provision through quality and compassion	• Increasing multi-drug resistant pathogens with decreasing antibiotic choices

Implementation Plan/Procedures

The educational intervention translated best practice evidence for the nursing staff on the pilot unit to relocate the intended beginning point of extended piperacillin/tazobactam infusions. Clarification of the time-dependent pharmacodynamics emphasized the importance of beginning the infusion as the medication enters the patient's bloodstream, instead of the medication's exit from the medication container. Nurses were instructed to follow a recommended administration process similar to the current practice with one major addition, a 25 mL manual secondary bolus using the smart pump to displace the dead space volume in the infusion tubing currently creating the infusion delay. This process clears the secondary and primary dead space volume of saline between the medication container and the patient's bloodstream; thus, relocating the beginning of the infusion to the patient's bloodstream as the physician orders intended. This process is compatible with either continuous infusions of intravenous fluids or saline locked devices.

Intervention and Measurements

A self-instruction module (see Appendix B) and demonstration video was emailed to each full- and part-time unit staff nurse (80 total nurses) by their unit management team. Completion of the self-instruction module was mandated within a two-week period. A post-instructional summative evaluation of five multiple choice questions (included in Appendix B) and a signed attestation of understanding of the information presented (included in Appendix B) was submitted to the unit supervisor by the end of the two-week self-instruction period. The project manager scored all summative

evaluations and analyzed data using descriptive statistics. Evaluation results were confidential.

Post-instructional application of information was randomly observed and evaluated by the project manager for consistency and accuracy for a four-week period using a checklist based on the new extended antibiotic infusion policy. An average of 25% of patients on the 41-bed unit were receiving this extended infusion and 11 nurses were staffing each day. Both day and night shift nurses monitored between 0600 and 1500 until at least half of the unit nurses were assessed for compliance with the new procedure. Monitoring included direct observation and personal staff interviews. The nursing administration of infusions was randomly observed in patient rooms during the monitoring phase without any recording of patient or nurse information whatsoever. For each randomly selected infusion, information about how the nurse was administering the medication was easily reviewed using the pump keypad to establish whether the instruction module was understood and followed. This was an additional opportunity for individual remediation to be offered by the project manager as needed. The only nurse information needed during the monitoring phase was to check off nurses' names that were observed, so they were only observed once.

The final outcome measure was a staff survey (see Appendix C) about the instruction module and staff nurse perceptions of the redefinition application. An online Survey Monkey link was emailed to all nurses with an explanation and instructions (see Appendix C). The project manager analyzed data using descriptive statistics and collated answers to the last two questions regarding concerns and feedback.

An overall summary of results was to be shared with associated physician, nursing, and pharmacy representatives throughout the project site via personal communication, PowerPoint presentation, or email. Ultimately, pilot project results were to be presented to the Nursing Practice Council, during the May 2018 meeting, with recommendations to facilitate system-wide practice improvements.

Cost Analysis/Budget

Multiple researchers have reported reductions in mortality and LOS with the implementation of extended antibiotic infusions (Heinrich et al., 2011; Falagas et al., 2013; Maddox et al., 2014; Yusuf et al., 2014). Extended infusions have been widely documented as beneficial due to enhanced exposure of bacteria to antibiotic therapy with a cost-effective bonus of using less medication (Droege et al., 2016). Fiscal and physical resources necessary for this practice implementation project would be limited to time expenditures; equipment and supplies are already present due to current infusion practices. Time would be needed for a system needs assessment, data analysis of current practices, education of nurses about best infusion evidence, policy development and implementation, evaluation of updated practice application through direct observation, and quality improvement process enhancement to sustain quality practice and optimal care outcomes. Costs associated with LOS, clinical outcomes, and mortality are considerable, multifaceted, and remain beyond the scope of this practice improvement initiative.

Table 4

Project Timeline

Project Timeline	
Summer 2017	
Problem Recognition	June 2017
Preliminary Literature Review of Problem	July 2017
Needs Assessment	July 2017
Expanded Literature Review for Best Practice	July 2017
Organizational Assessment	July 2017
Development of Goals and Outcome Objectives	August 2017
Development of Mission Statement	August 2017
Fall 2017	
Complete CITI Research Training	September 2017
Theoretical Underpinnings	September 2017
Work Planning	October 2017
Evaluation Planning	November 2017
Continuing Practice Immersion Experience	November 2017
Register for Spring 2018	December 2017
Complete and Submit Project Proposal	December 2017
Spring 2018	
Apply for GWU Summer Graduation	January 2018
Application for Hospital IRB Exempt Status	January 2018
Application for GWU IRB Exempt Status	January 2018
Implementation	February 2018
Implementation Monitoring	March 2018
Data Analysis and Aggregation	April 2018
Implementation and Practice Immersion Closure	May 2018
Recommendations to Nursing Practice Council	May 2018
Evaluation	May 2018
Summer 2018	
Written Dissemination/	June 2018
Oral Dissemination	July 2018
Electronic Dissemination/Manuscript Preparation	July 2018
ProQuest Submission	July 2018
Graduation	August 2018

SECTION VII

Implementation

Methodology

This quality improvement project piloted an educational initiative to inform nursing staff on one nursing unit of best practice evidence affecting extended antibiotic infusion management. Two project initiatives were implemented:

(1) Nursing Educational Initiative

- Self-instruction module (see Appendix B) translated evidence about time dependent antibiotic infusions for improved administration
- Demonstration video link supported the self-instruction process
- Post-instructional summative evaluation (five questions) determined understanding of new information
- Post-instructional staff survey (see Appendix C) evaluated resulting consistency and competency with extended infusion management
- Post-instructional application randomly monitored by direct observation of administration and personal staff interviews during scheduled piperacillin/tazobactam therapy

(2) Inter-professional Awareness

Pilot project results were shared with pharmacist Shannon Holt, Pharmacy and Therapeutics Committee (P&T) Systemwide Chair, Dr. Eric Raasch, and Infectious Disease Specialist, Dr. Chis Ingram. Pilot project results were presented to the Nursing Practice Council by May 2018 with recommendations for system-wide use.

Demographics

Seventy-three nurses employed on one unit in the selected organization during the pilot project period were mandated by their management team to participate in this quality improvement pilot project. Pertinent participant demographics regarding nursing experience and nursing education, described in Table 5, demonstrate the majority of nursing staff on the pilot unit is both highly experienced and well-educated.

Table 5

Experience and Education of Unit Staff Nurses

Experience and Education of Unit Staff Nurses

Experience	Nurses
0 – 3 years	22 (30%)
3 – 5 years	3 (4%)
5-10 years	15 (21%)
>10 years	33 (45%)

Education	Nurses
ADN	20 (27%)
BSN	52 (71%)
MSN	1 (1%)
National Medical-Surgical Certification	23 (32%)

Intervention

Implementation of the educational intervention was accomplished using an electronic self-instructional strategy. This pilot was intended to determine the effectiveness of the self-instruction strategy in the quality improvement of the administration of this extended infusion. The electronic self-instructional process could be easily replicated system-wide following this pilot project. The self-instruction module (see Appendix B) was emailed to each full- and part-time unit staff nurse (73 total nurses) by their unit management team. The management team decided to mandate the self-instruction in the interest of quality improvement. Attestations for staff nurses to submit by a certain date were included in the email, however no penalty was communicated or planned. Completion of the self-instruction module was mandated within the two-week period in March of 2018. No additional instruction was provided to the staff nurses regarding the new extended antibiotic infusion procedure. A post-instructional summative evaluation of five multiple choice questions and a signed attestation of understanding of the information presented were included in the self-instruction to be submitted to the unit supervisor by the end of the two-week self-instruction period. The project manager scored all summative evaluations to maintain participant confidentiality.

Post-instructional application of information was randomly observed and evaluated by the project manager for consistency and accuracy for a three-week period. A checklist based on the new extended antibiotic infusion process was used throughout the monitoring period. The project manager monitored the process application by direct observation and personal staff interviews regarding variables affecting the duration of the infusion. The nursing administration of infusions was randomly observed in patient

rooms during the monitoring phase without any recording of patient information. Information regarding instruction and instruction application obtained during staff nurse interviews was recorded without any specific nurse identifiers. Information was observed on the smart pump during administration or communicated by the nurse regarding each randomly selected infusion to establish whether the instruction was followed. For each randomly selected infusion, information about how the nurse administered the medication was easily reviewed using the pump keypad to establish whether the new procedure instructions were followed.

An anonymous staff survey (see Appendix C) was encouraged to be completed as an outcome measure of this pilot project. If staff nurses opted not to complete the voluntary survey, they were advised to delete it without penalty. An explanation and instructions for the staff survey were emailed by the unit management team to all unit nurses with a Survey Monkey link. This email was resent to all unit nurses two weeks later.

An overall summary of results was presented to the Nursing Practice Council with recommendations for a policy update to correct infusion infractions system-wide. Results were also shared with physician and pharmacy representatives.

SECTION VIII

Findings

The goal of this project was to evaluate the effectiveness of a self-instruction module in improving the quality of the extended antibiotic infusion process. Intended outcomes were to observe consistent and competent application of best practice evidence following self-instruction on one nursing unit during random infusion monitoring. This was measured after the instruction period by direct observation of smart pump dose delivery settings associated with administration of random extended antibiotic infusions. These findings were dependent upon the self-instruction module completion by staff nurses and their understanding of the best-practice evidence provided. Staff nurse understanding was validated using two methods, a summative multiple- choice assessment and a self-reporting survey.

Instruction Effectiveness

First, the effectiveness of the self-instruction module was evaluated immediately upon completion by each staff nurse using a five-item multiple-choice summative post-test assessment. Of the 73 nurses who were emailed a self-instruction module, a total of 30 (41%) nurses submitted an attestation for completing the instruction. Each nurse completing the instruction responded 100% correctly to all five post-test questions (150 questions/150 correct).

Second, the self-instruction effectiveness was evaluated several weeks following completion using an anonymous staff survey (see Appendix C). All 73 staff nurses were emailed a Survey Monkey link to self-report responses indicating personal reflections about understanding of the instruction and practice application of the instruction. Of the

30 nurses completing the instruction, nine nurses (30%) responded to the staff survey. All respondents either agreed (38%) or strongly agreed (62%) with every item. Three respondents reported having administered the infusion using the new process. No problems were encountered. (Table 6 & 7).

Table 6

Staff Survey Ratings

Staff Survey Ratings		
	Agree	Strongly Agree
1. Instructions easy to understand *(knowledge)*	5	4
2. Completion time reasonable *(skill)*	5	4
3. Infusion management awareness improved *(knowledge)*	4	5
4. Time dependent antibiotic awareness improved *(knowledge)*	3	6
5. Comfortable implementing new process *(skill)*	3	6
6. Quality improvement for patients *(attitude)*	2	7
7. Quality improvement for nursing practice *(attitude)*	2	7

Table 7

Collation of Staff Survey Comments

Collation of Staff Survey Comments	
	Total
Clear and easy to understand	3
New information	1
Shocked to realize infractions	1

Instruction Application

Following the instructional intervention to improve staff nurse understanding of time dependent antibiotic administration, evaluation of consistent and competent application of the learning was measured. Over a period of three weeks post-instruction, 29 infusions were randomly selected for direct observation (see Appendix D). All shifts were monitored. Six days of the week were monitored (excluding Sunday). Of the randomly observed post-instruction infusions, 17 of 29 pumps (59%) were programmed to infuse according to the instruction. This was evidenced by observation of the secondary volume to be infused (VTBI) programmed at 25 mL indicating the dead space volume had been deliberately adjusted by the nurse after the priming bolus. In three of those observations, the VTBI remained at 50 mL, so the nurse was interviewed for affirmation the priming bolus had been performed. In addition to observation and/or interview, a primary fluid flush rate of 12.5 mL indicated the nurse had completed the instruction and accurately applied the new infusion procedure (see Figure 4).

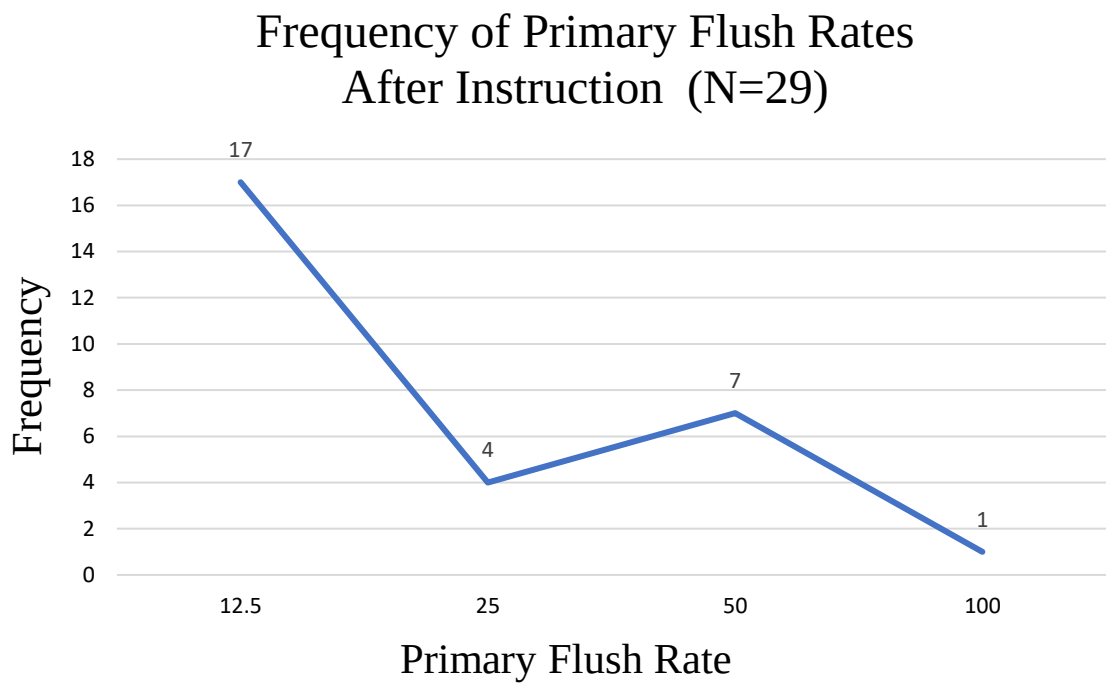


Figure 4. Frequency of Primary Flush Rates after Instruction

Measurement of Pre and Post Instruction Durations

The intended duration of the extended antibiotic infusion is four hours (240 minutes). Prior to instruction, durations ranged from 132 minutes to 144 minutes. This means that durations of the infusions ranged from 55% to 60% of the duration that was ordered to be administered. No infusions were found to be accurately delivering the four-hour duration as ordered.

Shortest durations:

The shortest infusions flushed for 12 minutes (20 mL at 100 mL/hr).

Longest durations:

The longest infusions flushed for 24 minutes (20 mL at 50 mL/hr).

Following the instruction period, 17 extended infusions were observed being administered according to the instruction. These infusion durations were 240 minutes or 100% the four-hour duration as ordered. Therefore, post-instruction, 100% of infusions were found to be accurately delivering the therapeutic four-hour duration. The remaining monitored infusions varied in shortened duration ranges consistent with pre-instruction findings.

Measurement of Pre and Post Instruction MIC

The intended infusion duration for piperacillin/tazobactam is T > 50% at MIC, or 50% of the eight hour dosing interval at the minimum inhibitory concentration. Prior to instruction, the shortest infusions flushed for 12 minutes (20 mL at 100 mL/hr) or 28% at MIC. The longest infusions flushed for 24 minutes (20 mL at 50 mL/hr) or 30% at MIC. The average of these, 29% at MIC, represents an overall shortened and sub-therapeutic pre-instruction infusion process. In comparison, the post-instruction 50% at MIC represents a therapeutic infusion duration in 100% of observations. (Figure 5).

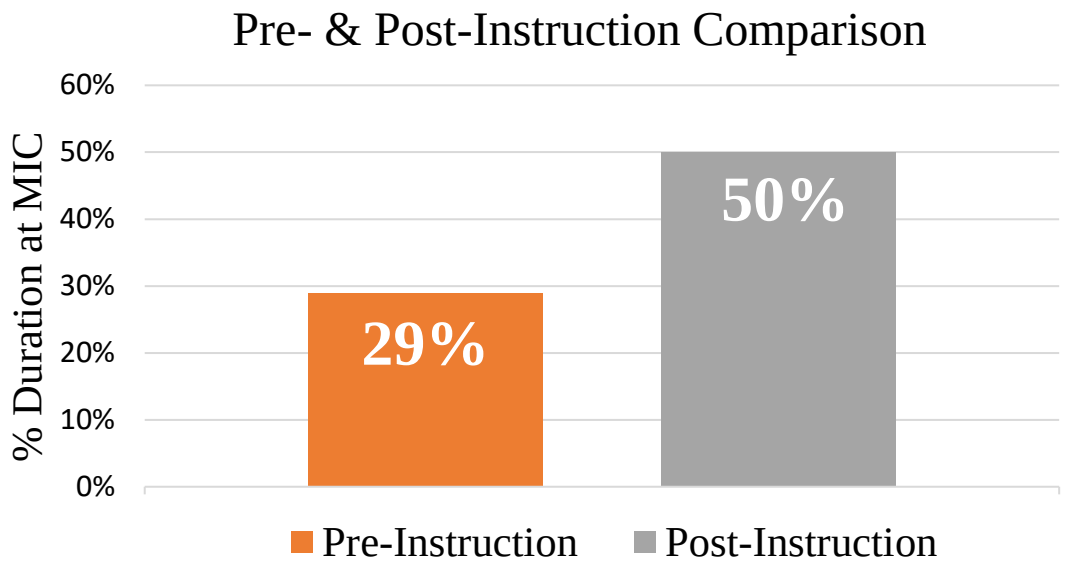


Figure 5. Pre and Post Instruction Comparison

SECTION IX

Interpretation of Findings

Instruction Effectiveness Evaluation

Interpretation of project findings substantiates the overall effectiveness of the self-instruction module in improving extended antibiotic infusions. Based on post-test results immediately following instruction and staff surveys weeks later, nurses associated the instruction with individual understanding of the new information. One hundred percent of 150 post-test questions were answered correctly by nurses upon completing the instruction. In addition, nurses responding positively to the staff survey several weeks following instruction indicates retention of the new information.

A staff survey response of 30% represents a typical and acceptable rate. Survey items investigated individual nursing knowledge (items 1,3, and 4), skill (items 2 and 5), and attitude (items 6 and 7) of the respondents about the instruction. Respondents unanimously indicated positive opinions toward the self-instruction and its application to their practice. Likert ratings for the first seven survey items vary slightly. More respondents agreed with items associated with ease and effort (2 of 7) than strongly agreed. More respondents strongly agreed with remaining items (5 of 7) than agreed. This suggests consideration and evaluation on the part of the respondents prior to selecting their responses. Respondents consistently value the overall instruction and feel confident to apply their new learning to patient care. In addition, respondents unanimously recognize system-wide benefit to the instruction.

Collation of survey comments also supported the positive overall response to the self-instruction module. The lengthiest comment communicated shock at the realization

of the infusion infractions. One nurse's expression of concern over tiny bubbles resulting from the priming bolus speed is worth noting. This nurse preferred to prime the tubing at a rate of 400mL/hour and clamp the primary tubing with an instrument clamp for the four minutes the prime takes at that rate. This is an individual nurse preference that in no way alters the infusion duration from the new procedure.

Instruction Limitations

Two limitations were identified during the implementation of this pilot project that had a significant effect on the instruction. Both limitations were related to the accessibility of the instruction module for completion by the unit nurses. The first limitation was the ineffective email delivery to the nurses. Emails delivered to the nurses were not necessarily visible to the nurses. The email issue was discovered when the instruction period concluded with only 16 of 73 attestations for completing the mandated instruction. Further investigation revealed the enormous quantity of emails received daily by each nurse. The overwhelming quantity resulted in the habitual neglect of nurses to check their email. Hypothetically, if a nurse failed to check email for two days, that nurse would likely never see a mandated item. In this case, the nurses were anticipating the mandated instruction introduced by their management team, yet the majority of nurses never realized it had arrived. The instruction period was extended for an additional two weeks to allow more nurses an opportunity for completion.

As the monitoring phase began, it became clear that many nurses had still not seen the instruction module. During this time, a second limitation was identified. Float pool nurses were regularly assigned to the pilot unit throughout the pilot project period. Float pool nurses were not included in the instruction module delivery email and,

therefore, could not complete the instruction. Notations were made when a float pool nurse was identified as administering the infusion during the monitoring period. Though these limitations were identified, they had no direct bearing on the overall results, as only the data from nurses who had completed the instruction were examined, collated, and considered.

Instruction effectiveness findings validate the achievement of instruction understanding by the nurses who attested to completing the self-instruction module. This is evidenced by perfect post-test scores as well as individual nurse reporting in survey responses. The instruction application evaluation demonstrates the post instruction consistency and competency of nurses during random infusion monitoring.

Instruction Application Evaluation

Direct observation of 29 randomly selected infusions validated consistent and competent application of the new extended infusion procedure by staff nurses post instruction. This was evidenced by 100% of nurses demonstrating capability and accuracy in using the new procedure throughout the three-week post instruction monitoring period. In addition, despite limitations in accessibility of the self-instruction, infusions programmed for 100% of the duration ordered increased by 72% post instruction.

The duration problem created by the DSV is two-fold on both the front and back ends of the extended infusion. Nurses must demonstrate that the infusion is primed to the patient's infusion site before beginning the infusion. Nurses must also demonstrate that the infusion is flushed at the same rate of the infusion while residual dead space volume containing medication continues to infuse. Monitoring strategies validate which nurses

primed and flushed accurately using the new procedure. Since no nurses were found to prime or flush infusions accurately pre-instruction and the procedure in the instruction is new to the nurses, accurate use of the new procedure post-instruction indicates completion of the instruction. Therefore, of the nurses indicating completion of the self-instruction with accurate programming of their smart pump, 100% demonstrate consistent and competent application of instruction.

A comparison of pre and post instruction durations also substantiates the consistent and competent application of instruction by the nursing staff. Seventeen infusions observed delivering the complete four-hour duration post instruction quantifies the effectiveness of the self-instruction. In terms of the MIC required for effective therapeutic patient benefit, findings are consistent. The average range of infusion duration pre-instruction translates to an average of 29% at MIC, which is significantly sub-therapeutic. The post-instruction duration of 50% at MIC represents delivery of the complete duration of medication as ordered in 100% of observations. The difference in duration time at MIC pre and post instruction demonstrates an improvement of 72% in the therapeutic duration delivery of piperacillin/tazobactam (50-29 = 21; 21/29 = 72% duration improvement).

Comparison to Literature

Nursing-led implementations such as this pilot project were not encountered in the literature. Infusion-associated implementations are most often pharmacy-led efforts due to the pharmacological impacts involved. Inter-professional collaboratives surrounding infusion administration should optimally include nursing input. The literature continues to reveal an ongoing gap in nursing infusion management cognition.

Gaps also continue to surround the recognition of beneficial support opportunities involving smart pump safeguards and capabilities.

A sustainable system-wide implementation to improve extended antibiotic infusions will require an ongoing awareness of and sensitivity to variations among individuals and groups involved with the change. It is important to involve persons who are considering a practice change in identifying the problems as well as determining an action plan. The change process will be a deliberate buy-in choice for each staff member. Porter-O'Grady and Malloch (2015) warned that variables including readiness for change and subtle group dynamics could influence stakeholders throughout the change process and should be closely monitored. The Society of Critical Care Medicine (2017) recognized two helpful strategies when implementing a practice initiative. One recommended strategy was to minimize the number of steps associated with the change. The second strategy was to maintain consistency among the steps whenever possible to minimize the risk of confusion or misinterpretation. These strategies were respected during the development of the new infusion procedure included in this pilot project.

Comparison to Swanson's Theory of Caring

Kristen Swanson clearly outlined the ideal framework supporting this pilot project to improve extended antibiotic infusions. Inaccurate delivery of infusion therapy is a nursing practice issue that impacts client well-being, one of the four phenomena she identified as common to nursing practice. The five caring processes direct nurses toward a therapeutic outcome that recognized nursing knowledge as integral to tailoring individual patient care. Being with, doing for, and enabling, the final three caring

processes, sustain the nursing responsibility for optimizing an infusion process that patients perceive to be ideal in meeting their therapeutic needs.

Recommendations

As a result of this scholarly pilot project, several recommendations associated with the practice problem and proposed solution are indicated. Findings validate the effectiveness of the self-instruction module in improving the delivery of extended antibiotic infusions. Nurses are consistently and competently applying the new infusion procedure to their practice following completion of the self-instruction module. First, system-wide instruction should be mandated to improve the extended antibiotic infusion process to that which is ordered, expected, and therapeutic for patients. Next, strategies other than a single email must be used to make the instruction accessible to all nurses. Third, a demonstration video provided with the self-instruction module was never mentioned by any of the nurses. Instruction on a larger scale would be best supported by a video with enhanced visibility so that visual learners could benefit by being able to read the smart pump settings.

A few minor alterations were made to the new infusion procedure following staff surveys, direct observation, and interviews of the nurses. A majority of survey respondents felt least agreeable with ease and effort items, so adjustments were made to shorten the overall written procedure. These alterations were included in the procedure presented to the Nursing Practice Council. No backpriming is needed prior to priming the infusion tubing with medication. This is, however, a difference in procedure from administering any other secondary infusion and it would not affect the new procedure if

the nurse preferred to continue the routine. Backpriming is still a requirement when changing the secondary tubing. The VTBI was altered to match the secondary and primary programming. With this alteration, the nurse would more easily program both the secondary and primary bags with the same rates and VTBI. The option to slow the priming bolus rate was added along with the rationale that it lengthens the priming time. Some nurses prefer to slow the priming bolus; this does not affect the infusion duration. The option for nurses to clamp or pinch primary tubing during the priming bolus also has no effect on the infusion duration. Disconnection of the infusion tubing between infusions was also recommended for enhanced patient mobility.

Conclusion

The solution to the practice problem including a new infusion procedure was piloted on one unit and evaluated for efficacy. Results and recommendations regarding system-wide implementation were presented to the Nursing Practice Council in May of 2018 and are currently being considered. The proposed medication bolus into the tubing serves to redefine the beginning of the extended antibiotic infusion to that which was ordered for the duration which was ordered. The intended beginning of an antibiotic infusion is the patient's intravascular space, not the infusion tubing. This redefinition should be recognized by nurses system-wide for the accurate administration and consistent delivery of time dependent medications over the duration periods ordered by physicians.

Documentation appeared that infusions were administered correctly over four hours as ordered, but direct observation at bedsides revealed that was not true. Direct observation of the post-instruction application by staff nurses revealed a 72%

improvement in duration delivery despite significant issues regarding accessibility of the instruction.

This scholarly practice project is intended to culminate in a system-wide awareness of a significant practice problem with direct impact on the success of clinical patient outcomes. Although assessment of clinical outcomes would exceed the scope of this project, the educational intervention pilot to redefine the appropriate beginning of the extended antibiotic infusion is a sustainable solution to this practice problem. The quality improvement of extended infusions on the pilot unit following self-instruction is significant. Recommendations resulting from this redefinition pilot project are intended to facilitate a system-wide extended infusion policy update to improve the delivery of extended antibiotic infusion durations for patients experiencing infections.

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Appendix A

Literature Review Matrix

Author	Title	Journal	Purpose	Key Points	Evaluation of Article
Alexander, E., & Zomp, A	Best practices: Full-dose delivery of intravenous medications via infusion pumps.	*Critical Care Nurse*	Raises awareness of dead space infusion tubing volumes and residual IVPB overfill and examines dose precision and potential clinical significance	Doses delivered using only primary tubing less suitable for smaller total dose volumes due to significant dose residual in tubing.	For the specific 50mL preparation of Piperacillin/tazobactam used in project organization, up to 60% of the dose can be lost to residual tubing volume post infusion.
Claus, B., Buyle, F., Robays, H., & Vogelaers, D.	Importance of Infusion Volume and Pump Characteristics in Extended Administration of β-Lactam Antibiotics	*Antimicrobial Agents and Chemotherapy*	Discusses common practice dilemmas of infusion line dead space and residual dose loss in a Belgian hospital	Up to 40% of antibiotic dose lost if tubing not flushed following dose (replacement of line dead space) versus not replacing deadspace as with primary tubing risks infusion of degraded drug with next infusion.	Dilemmas must be addressed with implementation of new infusion protocols.
Droege, M., Van Fleet, S., & Mueller, E.	Application of antibiotic pharmacodynamics and dosing principles in patients with sepsis.	*Critical Care Nurse*	Update for nurses about antibiotic pharmacotherapy in association with sepsis	Administration strategies are integral in achieving optimal patient outcomes.	Researchers update nurses about best evidence regarding antibiotic therapy with direct application to the physiology of sepsis. Education includes time vs concentration dependency, or both.
Falagas, M., Tansarli, G., Ikawa, K., & Vardakas, K.	Clinical outcomes with extended or continuous versus short-term intravenous infusion of carbapenems and piperacillin/tazobactam: A Systematic review and meta-analysis.	*Clinical Infectious Diseases*	Review of 14 studies of 1229 patients to determine whether longer durations of piperacillin/tazobactam or carbapenem infusions were associated with decreased mortality	Patients with either pneumonia or other infections demonstrated significantly lower mortality with extended or continuous piperacillin/tazobactam infusions than with short-term infusions. Only 3 of 14 were RCTs but randomization may be difficult.	Researchers reviewed PK and PD properties; Both are time-dependent antibiotics where the duration of intravascular exposure of the pathogen to the antibiotic determines the clinical effectiveness. Carbapenems = 40% MIC and piperacillin tazobactam = 50% MIC. Short-term infusions may allow pathogens to mutate into resistant strains.
Fan, S., Shum, H., Cheng, W., Chan, Y., Leung, S. M., & Yan, W	Clinical outcomes of extended versus intermittent infusion of piperacillin/tazobactam in critically ill patients: A prospective clinical trial.	*Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy*	single layer open-label prospective study in Hong Kong	367 pts in a 22 bed ICU in Hong Kong received Pip/taz for at least 48 hrs; 182 EI and 183 non EI; Significant (p=.01)14day mortality benefit in EI vs 30min infusion in pts with identified resp infections	

Felton, T., Hope, W., Lomaestro, B., Butterfield, J., Kwa, A., Drusano, G., & Lodise, T.	Population pharmacokinetics of extended-infusion piperacillin-tazobactam in hospitalized patients with nosocomial infections.	*Antimicrobial Agents and Chemotherapy*	Investigation of the pip/taz pharmacokinetic influences	Assurance that T>50%MIC was observed	Extended pip/taz infusions determined to be best practice for treatment of nosocomial infections
Harding, A. D.	Increasing the use of 'smart' pump drug libraries by nurses: A continuous quality improvement project.	*The American Journal of Nursing*			
Heinrich, L. S., Tokumaru, S., Clark, N. M., Garofalo, J., Paek, J. L., & Grim, S. A.	Development and implementation of a piperacillin-tazobactam extended infusion guideline.	*Journal of Pharmacy Practice*	500 bed academic medical center;103 patients and 1215 pip/taz doses	Included dose, staff education, and implementation issues shared as lessons learned; pharmacist led development and implementation.	Each infusion monitored at each bedside for 5 weeks to ensure compliance with new guidelines and to make immediate corrections. Rates increased from 25 to 30mL/hr to complete 100 mL dose.
Kim, A., Kuti, J. L., & Nicolau, D. P.	Probability of pharmacodynamic target attainment with standard and prolonged-infusion antibiotic regimens for empiric therapy in adults with hospital-acquired pneumonia.	*Clinical Therapeutics*	Studied 5000 patients	Pip/taz least effective for all monotherapy studied but studied in Monte Carlo Sim as extended infusion	3 hr extended infusions of pip/taz not as effective as extended infusions of other beta lactams against late HAP, but all more effective than short infusions.
Kirkbride, G., & Vermace, B.	Smart pumps: Implications for nurse leaders.	*Nursing Administration Quarterly*			
Lam, W., Bhowmick, T., Gross, A., Vanschooneveld, T., & Weinstein, M.	Using higher doses to compensate for tubing residuals in extended-infusion piperacillin-tazobactam.	*Annals of Pharmacotherapy*			
Lee, G. C., Liou, H., Yee, R., Quan, C. F., & Neldner, K.	Outcomes of extended-infusion piperacillin-tazobactam: A retrospective analysis of critically ill patients.	*Clinical Therapeutics*	148 pts in critical care studied for the purpose of comparing EI versus TI pip/taz infusion effectiveness	Retrospective pre and post implementation study in Texas comparing extended and traditional pip/taz	Extended dosing strategy associated with an improved 30 day mortality thus may be an effective alternative strategy in gram neg infections in critical care.

Lodise, T., Lomaestro, B., & Drusano,G.	Piperacillin-tazobactam for pseudomonas aeruginosa infection: Clinical implications of an extended-infusion dosing strategy.	*Clinical Infectious Diseases*	Cohort study of 194 patients with pseudomonas infections;		
Maddox, M., DeBoer, E., & Hammerquist, R.	Administration of extended infusion piperacillin-tazobactam with the use of smart pump technology.	*Hospital Pharmacy*	Converted all pip/taz infusions to 4 hr every 8-12 hrs with smart pump technology.	Standardization to promote consistency and prevent administration errors.	Decreased average LOS (not sigif) but signif decrease in mortality; conservative cost savings estimate in 24 months of over $2 million.
Ohashi, K., Dalleur, O., Dykes, P., & Bates DW.	Benefits and risks of using smart pumps to reduce medication error rates: a systematic review.	*Drug Safety*	Addresses smartpumps and med error reduction		
Rotschafer, J. & Ullman, M.	Comparative pharmacodynamics of intermittent and prolonged infusions of piperacillin/tazobactam using monte carlo simulation and steady-state pharmacokinetic data from hospitalized patients.	*The Annals of Pharmacotherapy*			
Schmees, P., Bergman, S., Strader, B., Metzke, M., Pointer, S., & Valenti, K.	Outcomes of an extended-infusion piperacillin-tazobactam protocol implementation in a community teaching hospital adult intensive care unit.	*American Journal of Health-System Pharmacy*			
Skledar, S., Niccolai, C., Schilling, D., Costello, S., Mininni, N., Ervin, K., & Urban, A.	Quality-improvement analytics for intravenous infusion pumps.	*American Journal of Health-System Pharmacy*			

Trbovich, P. L., Cafazzo, J. A., & Easty, A. C.	Implementation and optimization of smart infusion systems: Are we reaping the safety benefits?	*Journal for Healthcare Quality*	Experimental study to test smart pump technology effects on medication administration safety. Recognizes programming errors despite hard limits of programmed drug libraries.	24 nurses were observed using 3 types of pumps and 7 repeated tasks (four intermittent and 3 continuous infusion tasks) so each participant completed 21 infusion tasks.	Recognizes programming errors despite hard limits of programmed drug libraries.
Trbovich, P., Pinkney, S., Cafazzo, J., & Easty, A.	The impact of traditional and smart pump infusion technology on nurse medication administration performance in a simulated inpatient unit.	*Quality & Safety in Health Care*			
Winstead, E., Ratliff, P., Hickson, R., Mueller, J., & Judd, W.	Evaluation of an alternative extended-infusion piperacillin–tazobactam dosing strategy for the treatment of gram-negative infections.	*International Journal of Clinical Pharmacy*	To assess the clinical and economic impact of a novel 3-h extended-infusion piperacillin–tazobactam dosing strategy for the treatment of gram-negative infections.	433 bed hospital in Kentucky; retrospective cohort study before and after implementation; 181 pts received pip/taz for at least 48 hrs.	Significantly (p=.002) reduced 30-day readmission with 3hr extended infusions of P/T
Xamplas, R., Itokazu, G., Glowacki, R., Grasso, A., Caquelin, C., & Schwartz, D.	Implementation of an extended-infusion piperacillin–tazobactam program at an urban teaching hospital.	*American Journal of Health-System Pharmacy*			Emphasis on quality assurance outcomes with institution of new extended pip/taz protocol
Yost, R. J., & Cappelletty, D. M.	The retrospective cohort of extended-infusion piperacillin-tazobactam (RECEIPT) study: A multicenter study.	*Pharmacotherapy*	RECEIPT Study (retrospective cohort of extended infusion pip/taz) with signif decrease in hosp mortality; 359 adults; multicenter retrospective medical record review; 14 hospitals selected varied in size and location to best represent broad population.	The primary outcome was mortality rate of the patients receiving extended infusion piperacillin-tazobactam versus those receiving non-extended infusion comparative antibiotics.	Extended pip/taz infusions demonstrated decreased mortality in the treatment of patients with gram-negative infections; Decreased mortality p=.05 and decreased LOS p<.01.

Yui Tsang, K. C.	Development and assessment of an interactive training tool to help reduce error rate associated with shared infusion volume management tasks	Dissertations & Theses @ Library and Archives Canada	Purpose of study was to develop and validate a training sim for critical care nurses to enhance decision-making regarding infusion volume management; intensive undertaking for 25 nurses at many levels. Trbovich was the faculty lead.	>200 page dissertation with complex simulation initiative to enhance shared infusion volume reasoning of 25 critical care nurses.	More complex simulation tool for critical care nurses but the underlying infusion volume management issues are the same.
Yusuf, E., Spapen, H., & Piérard, D.	Prolonged vs intermittent infusion of piperacillin/tazobactam in critically ill patients: A narrative and systematic review.	*Journal of Critical Care*	Systematic review comparing the effectiveness of extended versus continuous pip/taz infusions in Belgium. Moderate level of evidence (1 high quality RCT and at least 2 high quality retrospective studies show similar results) supporting the prolonged or extended pip/taz infusion as having better clinical outcomes than with intermittent infusions and should be preferred for critically ill patients.	The studies in the review were global but the RCT was done in the US (Lee et al 2012)	Excellent validation of extended pip/taz as best practice! Moderate is defined as level 2 of 1-5, 1 being the highest.

Appendix B

Quality Improvement of the Extended Antibiotic Infusion Administration Process: A Self-Instruction Module

Patricia Averre, MSN, RN, CNE

February 28, 2018

Quality Improvement of the Extended Antibiotic Infusion Administration Process: A Self-Instruction Module

Introduction

Extended antibiotic infusions, primarily four-hour piperacillin/tazobactam (Zosyn), were added to pharmacotherapy options at this hospital in 2010. Since then, several issues have emerged that jeopardize intended patient outcomes to extended infusion therapy. This project will pilot an educational initiative to inform nursing staff on one unit of current best practice evidence affecting extended antibiotic infusion management.

This self-instruction module will review time-dependent antibiotic use and current administration issues. An intervention will be introduced to redefine the beginning of extended infusions in relation to the patient and improve dose delivery for the duration periods ordered. The most important part of this self-instruction module will be its consistent application following completion. Please begin using this information immediately to improve the delivery of four-hour piperacillin/tazobactam (Zosyn) infusions for patients.

Purpose

The purpose of this instruction module is to improve the delivery of four-hour piperacillin/tazobactam (Zosyn) infusions using nursing management and stewardship strategies for consistent and compliant dose delivery needed by patients experiencing infections.

Objectives

Upon completion of this self-instruction module, participants will be able to:

1. Corroborate time-dependent antibiotics and clinical benefits to patients.
2. Redefine the beginning of the medication infusion in relation to the patient's intravascular space.
3. Document the beginning of the medication infusion in relation to the patient's intravascular space.
4. Ensure the four-hour duration of extended infusions in relation to the patient's intravascular space.

Instructions

1. Review the self-instruction module at your convenience within the designated two-week period: **2/28/18 through 3/14/18**
2. Answer the post-instruction questions and sign the attestation form. Submit both the test and attestation to Megan Swink by Wednesday, March 14, 2018.
3. Piperacillin/tazobactam infusion administration will be randomly monitored by direct observation and interview for a four-week period to evaluate the effectiveness of this instruction.
4. Complete an anonymous survey within four weeks of instruction to help improve the content of this module. The survey link will be emailed to all unit nurses via *Survey Monkey.*

Why are extended antibiotic infusions important?

Dynamic issues associated with infection create unprecedented demands for quality healthcare improvements and modifications. Prior to 2010, researchers found extended antibiotic infusions to be an effective treatment option with astounding cost savings.[1-3] As global extended antibiotic use increased, significant correlations between extended infusions, decreased mortality, and shortened lengths of stay have dominated the literature.[4-14] Advantages of extended infusions have clearly evolved beyond cost-savings. Piperacillin/tazobactam is a broad spectrum antibiotic but is currently one of the best defenses against gram negative infection. Extended piperacillin-tazobactam infusions are most commonly selected to target susceptible hospital associated infections such as fluoroquinolone-resistant P*seudomonas aeruginosa*, *Klebsiella pneumoniae*, *Escherichia coli*, or carbapenem-resistant Enterobacteriaceae (CRE).[1]

Antibiotic therapy has historically been guided by bacterial susceptibility to a certain antibiotic. Multi drug-resistant organisms (MDROs) to the most commonly used antibiotics have resulted in the emergence of alternative dosing strategies, such as the extended antibiotic infusion.[1,5] Certain antibiotics have proven in vitro to be most bactericidal when infused over an extended period, making them time-dependent antibiotics.[1,5,6,9] Minimal drug concentrations are needed to inhibit bacterial growth, but concentrations must remain constant for an extended duration in the bloodstream to effectively destroy bacteria. The time for effective bacterial killing established for piperacillin/tazobactam is 50% duration of the dosing interval (or four of the eight hour interval).[1-3] Receiving the entire dose too quickly interrupts bacterial exposure to the minimal inhibitory concentration (MIC) required to prevent bacterial growth (see Figure 1).[1,5,6] Therefore, although a bacterial pathogen may be susceptible to an antibiotic and the entire dose is administered, bacteria are given the opportunity to multiply between antibiotic doses. In a study of 5000 patients with hospital associated pneumonia, researchers found that three-hour piperacillin/tazobactam infusions were not as effective as other beta-lactams; but all were more effective than 30-minute duration infusions.[2] Administering time-dependent antibiotics too quickly has been associated with longer hospital stays and with greater mortality.[5,12]

In a cohort study of 194 patients with pseudomonas infections, Lodise, Lomaestro, and Drusano (2007) were the first to associate significant mortality and length of stay benefits with extended piperacillin/tazobactam infusions. Falagas et al. (2013) shared a meta-analysis reviewing fourteen studies of over 1200 patients and their findings relating extended antibiotic infusions to clinical outcomes. Piperacillin/tazobactam effectiveness was consistently enhanced with extended infusion durations. Significantly decreased mortality and lengths of stay were demonstrated. These findings continued to be corroborated by multiple researchers as extended infusions were integrated into global healthcare settings.[9-11,13,14]

Once piperacillin/tazobactam has been ordered as an extended infusion, it is critical that the infusion time begins when the antibiotic begins infusing into the patient's intravascular space. It is just as critical that the infusion duration continues to infuse slowly into the bloodstream for the entire four-hour period.[12,15] Alexander and Zomp (2015) reported up to 60% of the piperacillin/tazobactam dose can be lost to residual dead space volume. When the medication bag is empty, the dead space volume still contains a significant amount of drug that must also infuse.

What does this mean for nurses?

Stewardship

MDROs are the result of inconsistent and ineffective antibiotic usage.[17] Antibiotic *stewardship* refers to the deliberately organized interprofessional strategies to ensure optimal antibiotic usage in combating infectious diseases, and includes unprecedented nursing implications.[16-21] The American Nurses Association (ANA) and CDC have collaborated to emphasize the need for nursing involvement in antibiotic stewardship to improve antibiotic use in healthcare settings.[16] The CDC (2017) developed four core actions, including stewardship, to guide professionals in combating antibiotic resistance. The Joint Commission (2016) established a new standard for medication management teams in hospitals as of January 1, 2017, specifically requiring antimicrobial stewardship action in controlling MDROs. [22]

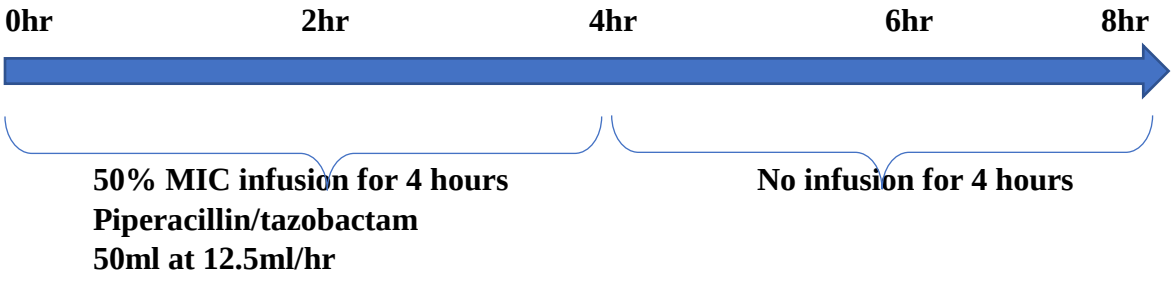
Dead Space

Dead space refers to the volume of the intravenous infusion pathway a solution travels from exiting its original container until reaching the patient's intravascular space.[8] Nurses manage dead space volume with every infusion. The amount of dead space is most significant when the infusion volume is small (less than 100 mL) and rates are slow (less than 20 mL/hour).[15] Dead space must be completely displaced by piperacillin/tazobactam before the medication arrives at the patient's intravascular space. Without this displacement, the slow rate of the extended infusion (12.5 mL/hour) creates an infusion delay in reaching the patient of approximately two hours (see Figure 1).

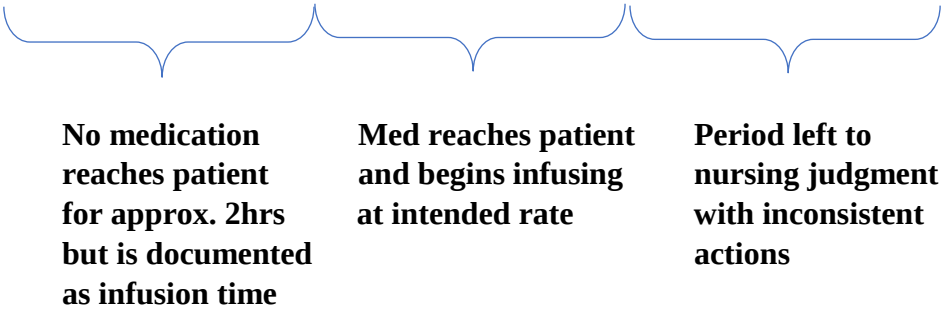
Infusion Delay Problem

Figure 1 ***Eight-hour Medication Frequency Timeline***

Intended infusion administration:



Duration problem with current infusion administration:



What is the solution?

There is a potential for significantly impacting patient benefits from extended infusions just by adjusting the current administration process. The solution to the practice problem involves redefining the beginning of the antibiotic infusion to get the dose to the patient for the duration ordered. This redefinition follows the same concept as administering an intravenous push medication. The intravenous medication doesn't reach the patient's intravascular space until the dead space (fluid occupying the tubing) is displaced by the medication. In addition, upon completion of the intravenous push, the medication is not completely administered until a post-medication flush displaces the residual medication still in the tubing. This same displacement principle can also be used to guide redefining the beginning of the extended antibiotic infusion.

Redefinition Guideline

A patient's infusion begins at the patient, not at the drip chamber of the medication bag. A 25 mL medication redefinition bolus will displace the dead space volume prior to beginning the antibiotic infusion. The pump will then need to be set to deliver 25 mL less in total volume. A post-infusion flush will be delivered at the same medication infusion rate until the tubing is cleared of medication. Using this process, patients will receive the ordered amount of medication for the ordered duration at the time documented in the EPR. This process is compatible with either continuous infusions of intravenous fluids or saline locked devices.

New Procedure: <u>WITHOUT</u> Continuous IV Fluid

Infusion Pathway:

(Backpriming is unnecessary when reusing dedicated tubing since tubing will be primed.)

1. **Prime** the tubing with 25 mL of medication bolus as directed in Table 1 below. [*When hanging new tubing, backprime the new secondary tubing with NS <u>before</u> spiking the new secondary bag to remove air for priming procedure.*]
2. **Set secondary VTBI for 25 mL <u>less than</u> secondary bag volume** (to account for priming).
3. **Set primary VTBI for 25 mL** (to flush infusion tubing following secondary infusion).
   Rate must be the same as the secondary medication rate because medication is continuing to infuse during this flush.
4. The infusion is complete when the smartpump alarm signals completion of the primary NS flush, a total duration of 4 hrs of intravascular exposure.
5. Disconnect the infusion pathway between extended infusions to enhance patient mobility.

New Procedure: <u>WITH</u> Continuous IV Fluid

Same above except:

1. Verify compatibility with continuous fluids
2. Continuous fluids will be delivered simultaneously using a separate smartpump.
3. Connect infusion tubing to the continuous IV fluid tubing via the port **<u>closest</u>** to the patient.
4. Optional to leave medication tubing connected during dormant intervals if smartpumps share one pole.

<u>Setting Summary</u>

Program priming bolus of medication:
Rate 999 mL/hr with VTBI 25 mL (must occlude primary tubing during bolus)

Set secondary IVPB and Primary flush the same:
Rate 12.5 mL/hr with VTBI 25 mL

Table 1
Medication Bolus Instructions

Nursing Action	Rationale
Hang the **new** medication container and open the clamp.	The secondary medication is ready for infusion.
[Backpriming is only needed when hanging new secondary tubing. ***Do not spike the new medication bag during backpriming.****]*	[***Spike medication bag after backpriming*** *new tubing to avoid adding any volume to the new medication bag. This maintains consistency of the priming bolus at 25 mL and reduces the risk of error.]*
Program a secondary *IV fluid bolus* rate at 999 mL/hr for a **VTBI of only 25 mL**.	**This redefines the beginning of the infusion as the patient's intravascular space** rather than the secondary drip chamber)
Press *run* to prime the infusion tubing **while pinching the primary tubing closed throughout the priming bolus**. The 25 mL priming bolus from the container to the patient will take 90 seconds and the smartpump will signal completion.	The rapid bolus rate will otherwise pull the bolus from both the primary and secondary containers, regardless of the lowered height of the primary fluid. The priming bolus must be pulled entirely from the IVPB to begin the medication infusion at the patient's intravascular space.
Reprogram the secondary infusion for the ordered rate of the four-hour infusion.	The medication infuses at the rate ordered.
Reprogram the secondary infusion VTBI for the amount in the container **minus** the 25 mL redefinition bolus.	The medication infusion pathway has already been primed with 25 mL of the medication, leaving less in the bag.
The primary fluid flush can be programed at this time. Set the primary fluid flush rate at the same rate as the medication ordered for a VTBI of 25 mL.	The primary fluid flush clears the residual medication from the tubing once the secondary container is empty. *Medication continues to infuse at the ordered rate during this time for up to two more hours.*
Attach the setup to the patient's access and press *run* to begin the extended infusion.	The medication infuses at the dosage ordered, for the duration ordered, in the intravascular space as ordered.
Documentation indicates accurate infusion begin and end times.	Documentation supports the patient's intravascular space as the beginning of the extended infusion.
The infusion is complete when the smartpump alarm signals completion of the primary fluid flush after a total duration of four hours.	The patient has received optimal intravascular extended exposure to the medication therapy as ordered.

Frequently Asked Questions & Answers

1. *Should I do this bolus with all IVPBs?*
   No. Other IVPBs infuse faster and reach the patient quickly. It's the slow rate of the extended infusion and the dead space volume (25 mL) that creates the significant infusion delay.

2. *Could I just use a primary IV set for the infusion?*
   That would deliver the med to the patient but traps significant residual (34%) med in the tubing at the end of the infusion. Repeated disconnections would be needed to flush the line. In addition, the unidirectional valve apparatus in the primary tubing differentiates the primary and secondary tubings for the pump. The secondary tubing could not be used as a flush with this system.

3. *What if I forget to occlude the primary line during the bolus?*
   You would see drops falling from both the primary and secondary bags meaning you were diluting the medication prime of the tubing. Be sure to also limit the VTBI to 25 mL!

4. *Why do we prime the line with 25 mL?*
   This is the average of the 21-28 mL dead space volume of various tubings, extensions, and catheters commonly used for infusion setups.

5. *Why would the IVPB policy not apply to this infusion?*
   It is the slow rate creating the two-hour infusion delay for the patient. Longer duration infusions must be managed differently, especially when rates are less than the dead space volume.

Post-test

Post Instruction Questions (Circle the correct answer and submit with the attestation form.)

1. The most significant evidence supporting patient benefits from extended antibiotic infusion therapy includes:
   A. Decreased mortality and lengths of stay
   B. Improved would healing and pain control
   C. Reductions in leukocytosis and thrombocytopenia
   D. Enhanced functional capacity and mental status.

2. Which statement describes the rationale for redefining the beginning of the extended antibiotic infusion?
   A. A patient's infusion begins at the patient, not the secondary drip chamber.
   B. Dead space volume between the secondary container and the patient creates the potential for a significant infusion delay.
   C. Time-dependent antibiotics need intravascular exposure time for effective bactericidal activity.
   D. All the above are correct.

3. In the redefinition process, what must the nurse be doing throughout the 90 second bolus?
   A. Monitoring patient response closely for any signs of adverse reaction or hypersensitivity
   B. No special intervention is needed during this time.
   C. Pinching the primary tubing closed so the redefinition bolus is only pulled from the secondary antibiotic container.
   D. Pinching the secondary antibiotic tubing closed so the redefinition bolus is only pulled from the primary container.

4. What would be the correct order of actions when administering extended antibiotic infusions using the improved process?
   A. Bolus, backprime, secondary infusion, primary fluid flush
   B. Backprime, bolus, secondary infusion, primary fluid flush
   C. Primary fluid flush, bolus, backprime, secondary infusion
   D. Secondary fluid flush, primary infusion, bolus, backprime

5. The redefinition bolus only applies to extended antibiotic infusions because:
   A. Dead space volumes are the same for all IVPB infusions so perhaps it should apply to all.
   B. Greater IVPB volumes infusing faster reach the patient much more quickly without significant delays.
   C. Small IVPB volumes and slow rates significantly delay the antibiotic from reaching the patient.
   D. Both B and C.

Quality Improvement of the Extended Antibiotic Infusion Administration Process: A Self-Instruction Module

Attestation Form

I have reviewed and understand the information provided in this self-instruction module.

Signature_____Date_____

Footnotes

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Appendix C

Extended Antibiotic Infusion Redefinition Project Staff Survey

DIRECTIONS: *Please indicate your response to the questions below as follows:*
***1**-Strongly Disagree* ***2**-Disagree* ***3**-Agree* ***4**-Strongly Agree*

I found the redefinition instructions easy to understand.	1 2 3 4
It took a reasonable amount of time to complete the self-instruction module.	1 2 3 4
My awareness of managing intravenous infusion volume is improved following the self-instruction module.	1 2 3 4
My awareness of time-dependent antibiotics is improved following the self-instruction module.	1 2 3 4
Upon completion of the self-instruction module, I feel comfortable implementing the redefinition process independently.	1 2 3 4
The redefinition process improves extended antibiotic infusion therapy for my patients.	1 2 3 4
I would recommend a system-wide implementation of the self-instruction module for nurses.	1 2 3 4
Have you administered extended Zosyn since completing the self-instruction module? If so, describe any problems or concerns you may have had implementing the redefinition process.	
In three sentences or less, provide feedback on the overall self-instruction module and implementation.	

Appendix D

Infusion Monitoring Results

	DATE	SECONDARY RATE	SECONDARY VOLUME	PRIMARY RATE	PRIMARY VOLUME
1	March 28, 2018	12.5	25	12.5	20
2	March 28, 2018	12.5	25	12.5	20
3	March 28, 2018	12.5	50	25	50
4	March 29, 2018	12.5	50	50	100
5	March 29, 2018	12.5	50	50	42
6	March 29, 2018	12.5	50	50	100
7	March 30, 2018	12.5	25	12.5	20
8	March 30, 2018	12.5	25	12.5	20
9	April 2, 2018	12.5	50	25	50
10	April 2, 2018	12.5	25	12.5	20
11	April 3, 2018	12.5	25	12.5	20
12	April 3, 2018	12.5	50	50	50
13	April 3, 2018	12.5	50	100	50
14	April 4, 2018	12.5	25	12.5	50
15	April 4, 2018	12.5	50	12.5	20
16	April 4, 2018	12.5	25	12.5	20
17	April 5, 2018	12.5	50	25	100
18	April 5, 2018	12.5	25	12.5	20
19	April 5, 2018	12.5	50	12.5	20
20	April 5, 2018	12.5	50	50	50
21	April 7, 2018	12.5	50	50	100
22	April 10, 2018	12.5	25	12.5	20
23	April 11, 2018	12.5	50	50	50
24	April 11, 2018	12.5	50	25	740
25	April 11, 2018	12.5	25	12.5	20
26	April 12, 2018	12.5	25	12.5	20
27	April 17, 2018	12.5	50	12.5	50
28	April 17, 2018	12.5	25	12.5	20
29	April 18, 2018	12.5	25	12.5	25