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Improving Antibiotic Administration Timing in Neonatal Early-Onset Sepsis

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Abstract

Neonatal early onset sepsis (EOS) remains one of the most common causes of neonatal morbidity and mortality. Neonates requiring evaluation and treatment for suspected EOS inconsistently receive antibiotics within one hour of decision to treat as recommended in the 2012 neonatal sepsis guidelines by the National Institutes for Health and Care Excellence (NICE). A mixed method quality improvement initiative was employed in a level three NICU, applying a standardized admission process to mitigate systems flaws impacting delay of first dose antibiotic. A nursing sepsis education module was provided, and the novel SAM admission prioritization tool was developed to guide neonatal NICU admission activities and teach nursing prioritization skills. Statistically significant improvement was achieved in the aggregate steps related to patient care activities (p<.001), pharmacy review of critical antibiotic orders (p<.001), antibiotic infusion timing (p<.001), and nursing desire and use of the novel SAM admission prioritization support tool (p=.009). Nursing knowledge related to antibiotic timing and prioritization skills improved (p=.038, p<.001). Several nursing correlations were discovered including a low positive correlation preintervention between years of nursing experience and desire for an admission support tool (r=-.302, p=.017) and a moderate positive correlation between a desire for the SAM tool and use of the SAM tool postintervention (r=.441, p<.001). Several themes were identified through nursing survey responses illustrating the complexities of the NICU environment that may magnify unique unmeasurable human factors impacting delay. The advanced practice nurse provides a unique perspective and skill set to facilitate collaborative teams to improve health care delivery and outcomes in this vulnerable neonatal population.

Key words: neonate, early-onset sepsis, neonatal sepsis, late preterm infant, golden hour, quality improvement, DNP project, antibiotic stewardship, antibiotic timing, neonatal sepsis

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Executive Summary

Improving Antibiotic Timing in Neonatal Early-Onset Sepsis

Problem: Neonatal early onset sepsis (EOS) remains one of the most common causes of neonatal morbidity and mortality. The surviving sepsis campaign (SSC) states the neonatal population is unique in their constellation of epidemiologic risk factors for EOS and the current pediatric sepsis guidelines do not apply to this population. Clear published benchmarks provide guidance for antibiotic timing in this high-risk neonatal population. Neonates requiring evaluation and treatment for suspected EOS inconsistently receive antibiotics within one hour of decision to treat as previously recommended by the National Institutes for Health and Care Excellence (2012). PICO: Will neonates with peripheral access requiring evaluation for EOS, through a standardized admission process, receive first dose antibiotic within 60 minutes from admission to the neonatal intensive care unit (NICU) more often than compared to preintervention?

Purpose: To investigate process improvement opportunities and mitigate identifiable delays in systems process elements that impact delay in first dose antibiotic infusion timing and improve consistent first antibiotic administration by 60 minutes of admission to the NICU.

Goals: Evaluate and mitigate systems flaws related to systems processes that impact antibiotic delay, refine human capital by increasing nursing, provider, and pharmacy knowledge related to neonatal sepsis. Establish care equity in the neonatal population similar to their pediatric and adult counterparts undergoing sepsis evaluations.

Objectives: Project objectives included a robust systems analysis surrounding the NICU admission process that may impact antibiotic infusion delays. Key stakeholder roles were evaluated including provider order entry and pharmacy notification of critical orders. Bedside nursing staff play an essential role in the downstream communication of essential patient information necessary to expedite and coordinate time-sensitive patient care activities.

Plan: Interventions included nursing pre/post intervention surveys, a nursing education module on neonatal EOS, and the development of a novel nursing admission prioritization support tool. Antibiotic orders were updated to STAT priority forcing prompt pharmacy review. Order entry timing and peripheral access placement data were evaluated for possible impact on the flow of aggregate systems elements. Interventions did not require staffing model changes.

Results: There was statistically significant improvement in the aggregate steps from decision to treat to first dose antibiotic timing following intervention ($p<.001$). Critical individual systems steps improved including clinical weight documentation, pharmacy review of orders, and antibiotic timing ($p<.001$). Despite the addition of new providers and significant nurse attrition, mean times improved for provider order entry timing and nursing peripheral access placement. These process elements were already acceptable yet lacked baseline unit level benchmark data. Nursing data showed improved nursing knowledge following intervention ($p<.001$, $p=.038$) and increased desire to continue with the novel SAM Admission Prioritization Tool ($p=.009$).

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This project is dedicated to my daughter Greta, may you never stop believing in your own potential.

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Problem Recognition

Neonates requiring treatment for early-onset sepsis inconsistently receive antibiotics within 60 minutes from decision to treat as recommended by the National Institutes for Health Care Excellence (NICE) (National Institutes for Health and Care Excellence, 2012). Despite improved obstetric management with intrapartum antimicrobial therapy when indicated for identified maternal *group B streptococcus* (GBS), early-onset sepsis in neonates remains one of the most common causes of morbidity and mortality in the preterm neonatal population (Polin, 2012). The purpose of this quality improvement project was to improve the time-sensitive management of neonates requiring evaluation and treatment for early-onset sepsis by improving antibiotic infusion timing within 60 minutes of admission to the neonatal intensive care unit (NICU) through a revised standardized neonatal admission process with a multidisciplinary approach.

Project PICO

This quality improvement (QI) initiative employed a Population-Intervention-Comparative-Outcome (PICO) format for the development of the study question investigated:

Population: neonates with peripheral access requiring evaluation for early-onset sepsis (EOS)

Intervention: through a standardized admission process

Comparative: compared to preintervention

Outcome: will receive antibiotics more often within 60 minutes of admission to the NICU

Project Question: *Will neonates with peripheral access and requiring evaluation for early-onset sepsis through a standardized admission process receive first dose antibiotic within 60 minutes of admission to the NICU more often than compared to preintervention?*

Project Significance

Despite improved obstetric management with intrapartum antimicrobial therapy when indicated, early onset sepsis in neonates remains one of the most common causes of neonatal morbidity and mortality in the preterm infant population (Polin, 2012). The population of interest included preterm and ill neonates in the first 72 hours of life requiring evaluation for EOS.

EOS in newborns is defined as a blood or cerebrospinal fluid (CSF) culture obtained within 72 hours after birth growing pathogenic bacteria (Puopolo et al., 2018). Several well-known risk factors for EOS include prematurity and gestational age at birth, maternal intraamniotic infection or chorioamnionitis, duration of rupture of membranes, maternal GBS colonization, appropriate intrapartum antibiotics if indicated, and newborn clinical presentation. Additionally, there exists a disproportionate number of infants born to mothers of African American race at increased risk of EOS, illustrating some of the important considerations of social determinants of health and epidemiologic factors (Puopolo, et al., 2018).

Neonatal risk factors are established on a myriad of perinatal risk factors that lack sensitivity and specificity. Available diagnostic testing methods have poor predictive value leading to empiric treatment for numerous well-appearing infants for an extended period despite negative blood culture results (Polin, 2012). New knowledge demonstrates that antibiotic treatment in preterm infants for greater than or equal to five days increases risk for late onset sepsis, necrotizing enterocolitis, and increased risk of mortality (Polin, 2012). Approximately a 10-fold number of preterm and term neonates are treated empirically with antibiotics that were ultimately considered unnecessary (Kerste et al., 2016).

While improvements have been made in establishing which neonates should be treated, a time-sensitive treatment management approach is warranted. Neonates requiring treatment for

EOS inconsistently receive antibiotics within one hour of decision to treat as recommended by the NICE and warrants urgent systems evaluation measures to mitigate identified delays (NICE, 2012).

Implications for the Doctor of Nursing Practice Role

While neonatal mortality and survival have improved over the previous 50 years, the burden of morbidity remains extensively varied. NICUs are complex environments and often part of larger hospital systems with a primarily adult focused population. This increased complexity leads to a higher risk for medical error resulting from complex processes and high-paced intensive care environments. Adopting a culture of quality and safety creates cohesive teams with a clear unified vision that enhances practice outcomes. Emulating high-reliable organizations requires strong leadership for a robust continuous-improvement culture to perform at a level of sustained excellence. The Doctor of Nursing Practice prepared advanced practice registered nurse is well-positioned to lead changes to improved patient outcomes, improved systems performance, and continued professional development (Lachman, Jayadev, & Rahi, 2014).

This project encompassed a demonstration of mastery of the advanced practiced skills necessary and desirable in today’s healthcare environment for the Doctor of Nursing Practice (DNP) degree. Competency in designing and leading quality improvement initiatives is an expectation across all healthcare settings, and DNP projects using quality improvement methodologies make valuable data-driven contributions to improve clinical and healthcare systems outcomes (Moran, 2020). The American Nurses Credentialing Center (ANCC) views the DNP graduate as an essential agent for quality improvement with an aptitude for complex systems thinking (Terry, 2018).

Theoretical Foundation

The utilization of nursing, leadership, and change theories provided a strong foundation and framework for this project.

Betty Neuman's System Model

Neuman's System grand theory model includes the foundation of client *wholism*, a dynamic process of client wellness on a continuum of interactions of variables with the environment. Theory assumptions include clients in the form of individuals, groups and communities that exist as dynamic open systems in constant interaction with the environment. Neuman defined a system as a pervasive order that holds together its parts (Appendix A) (Neuman & Faucett, 2011, p. 9).

The client system core structure includes a tapestry of five interacting variables including physiological, psychological, sociocultural, developmental, and spiritual, depicted pictorially as a series of concentric circles that represent system structure and stability (Lowry & Aylward, 2015). In this model, the client and caregivers form a partnership to form goals "for optimal health retention, restoration and maintenance" (Lowry & Aylward, 2015, p.166).

Systems Theory Analysis

Neuman defines three core theoretical concepts of the model that include the client system, the environment, and health. Neonatal early-onset sepsis evaluations are considered tertiary prevention interventions and while necessary, are disruptive to the neonate's system stability and usual transition to extrauterine life.

Client system

The client system describes five interacting variables including lines of defense. Flexible lines of defense are viewed as a buffer system and may include concepts such as sleep disruption and poor nutrition. The neonate has limited buffer abilities or flexible lines of defense, requiring acute awareness by the nurse to potential and actual stressor invasion (Lowry & Aylward, 2015). In the case of neonate requiring evaluation for early-onset sepsis, the neonate experiences a disruption of the maternal-neonate dyad, is unable to support expected nutritional or thermoregulatory stability, and is suspected to be fighting infection with little ability to communicate with caregivers.

Normal lines of defense represent the usual state of client wellness over time and protect the basic structure of the client. Neonates requiring evaluation for early-onset sepsis have limited normal lines of defense to both internal and external stressors, are a vulnerable population, and have limited capacity for self-advocacy. The bedside nurse is the essential neonatal advocate to limit stressors related to required clinical activities surrounding neonatal sepsis management and expedite timely critical patient care activities.

Environment

The concept of environment includes the internal, external, and created environments that influence the client's ability to adapt to stressors (Wills, 2019). The environment for the ill and preterm neonate plays a role in system stability and is often referred to as developmental care. Preterm and ill neonates experience a disruption in their intended developmental environment which is forced to interact with stimuli not previously present in utero. This includes separation from the mother, bright lights and noises, and stressful or painful procedures that have been shown to impact brain development and contribute to neurodevelopmental delay (Macho, 2017).

Health

Neuman defines health as existing on a continuum and is interpreted by the client's perception of the degree of wellness they are experiencing at any given time dependent on existing stressors and the client's usual existing lines of defense (Wills, 2019). In the case of the preterm or ill neonate, the intended growth and transition to the extrauterine environment has been interrupted causing a myriad of internal and external stress that may destabilize their system. The necessary interventions of day-to-day care for the ill and preterm neonate add additional stress maintaining system stability.

The client-caregiver relationship is intended as supportive and to not create additional stressors that may disrupt the balance of the client through essential care activities and tasks (Neuman & Faucett, 2011). The nurse therefore has a defined role to advocate and execute high-quality stabilization activities and is instrumental in supporting the family-neonate system through the critical NICU admission process as a basis to build a trusting relationship with preterm or ill neonate and their family.

Systems Theory Evaluation

As a grand theory and model, it cannot be easily tested in its entirety. However, the conceptual elements of Neuman's System Model can be used to test certain hypothesis. Prevention as an intervention includes minimizing or reducing potential or actual risk factors associated with the disruption or creation of environmental stress, mitigating possible reactions and adverse outcomes of the long-term effects from stressors such as pain producing procedures (Lowry & Aylward, 2015). Neonates in the NICU have experienced disruption in their optimal developmental environment, requiring additional efforts to decrease or prevent new and perhaps unnecessary stress. Testing prevention as intervention, environment stability, existing stressors, and wellness of infants in the NICU is possible with the use of Neuman's system model. For the application of this project, improving tertiary prevention strategies to maintain systems stability was crucial to support the ill or preterm neonate suspected of experiencing sepsis.

This theory has been utilized over several decades and has been applied to a variety of nursing settings including clinical, academic, and research arenas. This theory carries much integrity and validity in application to nursing practice at all levels and practice areas of nursing from novice to expert and maintains congruency with nursing standards of practice (Neuman & Faucett, 2011).

Transformational Leadership Theory

Implementation of evidence-based practice changes are frequently difficult to establish. Implementation and sustainability rates for successful quality improvement initiatives are often associated with the utilization of an implementation champion who is viewed as a leader with influence and charisma that can motivate others towards practice change and professional growth experiences (Zaccagnini & Pechacek, 2019).

Advanced practice registered nurses (APRN) are considered the "nexus of healthcare transformation" and often possess the motivation and charisma to influence practice change as team leaders (Zaccagnini & Pechacek, 2019, p. xi). A transformational leadership approach adopted by the APRN provider encourages engagement with nursing, the larger organization, and other providers to create valuable impact on practice changes to improve practice outcomes.

Transformational leaders bode a strong commitment to the nursing profession and to their organization and embody the ability to excite and motivate followers to create strong cohesive teams and a unified vision to achieve group goals (Oberleitner, 2019, p. 385). A good transformational leader communicates "a vision worth sharing, a goal worth achieving… and affirmation of the follower's worth" (Curtain, 1997, p. 8).

Transformational Leadership Analysis

Transformational leadership changes and transforms people through charismatic and visionary leadership. This leadership style is concerned and invested in the emotions, values, ethics, and long-term goals that are connected to the collective good. The leader engages in a dynamic relationship with followers to be able to assess their motives and have insight into their needs, treating them as full human beings. They are able to motivate followers to accomplish more than what is expected from them, or what they may even expect from themselves (Northouse, 2016).

By creating a roadmap to excellence, the APRN transformational leader creates progress and momentum by setting an example with consistent role modeling behaviors that establishes credibility of the mission and embodies the core of nursing as a profession (Zaccagnini & Pechaeck, 2021). Clavelle & Prado-Inzerillo (2018) describe a five-step approach to emulating transformational leadership including challenging the process, modeling the way, enabling others to act, encourage the heart, and inspiring a shared goal vision (Appendix B).

Transformational Leadership Evaluation

DNP prepared nurses must stay "attuned to and knowledgeable about practice changes, ensuring current best practice is maintained" (Zaccagnini & Pechacek, 2021, p. 69). APRN providers must advocate and become both active and motivational participants in the implementation of continuous quality improvement efforts to improve systems elements that may impact patient outcomes. This project required multidisciplinary adjustments to improve systems process that impacted antibiotic administration timing for neonates requiring evaluation and treatment for EOS.

Group dynamics and patient advocacy in the presence of high-stress situations such as the critical admission of a vulnerable neonate to the NICU can be challenging. Transformational leadership creates a mutual supportive vision for change in neonatal sepsis management standards that will motivate others towards an amplified standard of advocacy and sense of urgency for this vulnerable population. The DNP prepared APRN provider that embraces a transformational leadership approach "can be intentional in cultivating" a leadership style that is exemplary, "creating a positive and empowering esprit de corps that supports nursing excellence" (Clavelle & Prado-Inzerillo, 2018, p.39). Sustainability is crucial when establishing practice change. Followers will be motivated and inspired to become ongoing leaders in innovative problem resolution, champions for sustainment, and become active moral agents for ongoing attention to high-quality patient care practices (Curtain, 1997).

Kotter's Change Theory

Kotter's eight-step model for change provided an effective framework to embrace the culture of this quality improvement initiative. This model provided structure, vision and direction for the practice changes needed to achieve the goals outlined for timely antibiotic infusion timing. Early in project development, informal conversations with nursing, providers, and pharmacy staff revealed a uniform concern for perceived delay of antibiotic administration for neonates on admission to the NICU, and that previous efforts to mitigate systems hiccups have been repeatedly unsuccessful.

Kotter's model for change provided an excellent cultural fit for a transformational leadership approach in the development of the optimal project team to generate a sense of urgency and drive change from within. Utilizing this model proved helpful in framing interventional activities for this quality improvement initiative and established buy-in from necessary stakeholders. Key elements from this model included creating a sense of urgency, forming a guiding coalition, creating a unified vision, empowered others to act, and ultimately institutionalized new changes for sustainability (Appendix C) (Small et al., 2016).

Literature Review

A robust and comprehensive systematic review of the literature revealed an abundance of information regarding clinical practice trends to improve antibiotic stewardship in the treatment of early newborn sepsis (approach to the systematic review is presented in Appendix D). Search databases included CINHAL, Medline, and Academic Search Premier through the EBSCO search engine.

Initial search terms included ‘newborn’ AND ‘sepsis’ surfaced over 6,600 publications over the previous 20 years. Limiting the years narrowed available publications to just over 2,500 items. Further refining the search terms to ‘newborn’ AND ‘early sepsis’, ‘late preterm’ AND ‘sepsis’, and ‘newborn’ AND ‘EOS sepsis calculator’ revealed much of the most recent publications relevant to the focus of this project including early sepsis, late preterm infants, and the use of the novel early-onset sepsis calculator in the early-term and term rule-out sepsis population.

An intentional search of the literature was performed to obtain current practice guidelines from key professional organizations including the American Academy of Pediatrics (AAP), American Colleges of Obstetrics and Gynecologist (ACOG) and the National Institute for Health and Care Excellence (NICE). Seminal work on the epidemiology of the late preterm infant by Engle, Tomashek, & Wallman (2007) provides insight on this critical NICU population that often comprises as much as 70% of NICU census and reinforce this populations’ vulnerability for sepsis. A more recent update builds on this important work, further emphasizing a renewed approach for increased caution in these neonates.

Of over 30 focused publications that were retrieved and reviewed, 12 key publications remain pertinent to the focus of this project and are listed in Appendix E. Additional literature reviewed included other similar themed quality improvement projects in either NICU or pediatric intensive care unit (PICU) environments, quality improvement methodologies, and sepsis protocols in the adult and pediatric populations. Nursing, leadership, and change theories were also reviewed for applicability and goodness of fit for the project. The major themes that emerged from this search included consensus statements and practice guidelines from major professional organizations, other similar quality improvement projects, the concept of the importance of creating a sense of urgency as demonstrated by the *Surviving Sepsis Campaign*, and an overall lack of nursing theory to support practice change related to this problem.

While the AAP and ACOG address the current recommendations surrounding assessing risk for sepsis and defining who should be treated in a timely manner, only the NICE established a benchmark timeline for administration of initial antibiotics in newborns (NICE, 2012). Because of the known vague presentation of clinical illness in neonates, the practice of initiating broad spectrum antibiotic therapy in asymptomatic or vaguely symptomatic infants is not uncommon and has led to an overall decreased sense of urgency at the bedside during newborn admissions to the NICU. (Puopulo, 2018).

The Centers for Disease Control and Prevention (CDC) and the American Academy of Pediatrics (AAP) present guidelines for a risk-based approach that previously separated well-appearing infants from their mothers with recommendations for empiric antibiotic administration surrounding several risks factors including GBS status of the mother, maternal diagnosis of chorioamnionitis, or prolonged rupture of membranes during the labor and delivery process without regard to the presentation of the infant. These guidelines have since been updated after new knowledge surfaced during the development of the novel Kaiser Permanente EOS calculator with a more modest approach in establishing sepsis risk that remains safe and effective (Puopolo, et al., 2018).

The Kaiser Permanente early-onset sepsis calculator is a risk-assessment tool utilized to decrease the use of empiric antibiotic use in newborns at birth over the age of 35 weeks' gestation. This sepsis calculator addresses the increasing incidence of EOS respective to decreasing gestational age. The calculator also acknowledges that signs and symptoms of neonatal EOS are relatively non-specific in nature, historically prompting empiric over-treatment of otherwise well-appearing infants. This practice of empiric treatment in well-appearing infants with low risk for sepsis often requires separating the infant and mother, delaying maternal-infant bonding, interrupting breastfeeding establishment, increases length of hospitalization, impacts health care costs, and potentially increases adverse events associated with extended empiric antibiotic therapy (Kuzniewicz et al., 2017).

The improvements made in determining which infants should be treated have improved antibiotic stewardship by decreasing the frequency of initiation of antimicrobial therapy when indicated. Important epidemiologic considerations have been addressed guiding important considerations establishing risk for EOS for the late preterm infant population. Yet, moderate and late preterm infants between 30-weeks' and 36-weeks' gestation pose a different challenge for sepsis evaluation and treatment, as they are already at increased risk due to their decreased gestation at birth. Risk of sepsis is inversely related to gestational age, and these neonates may present with few symptoms similar to their older-gestational age neonatal counterparts. Risk assessment may also be complicated when preterm delivery has been prompted due to maternal indications such as severe gestational hypertension, growth restriction, or placental insufficiency complications of pregnancy (Puopulo, 2018).

The timely administration of prescribed antibiotics deserves equal attention in the context of antibiotic stewardship. Prompt evaluation of systems processes to decrease potential delay in the communication and administration timing of antibiotics for the neonate requiring evaluation for suspected EOS are essential. The NICE guidelines establish a clear benchmark for antibiotic administration timing in neonates within 60 minutes from the decision to treat (NICE, 2012).

Adult studies have shown a linear relationship for increased risk of mortality for every hour that passes after the onset of hypotension in the adult sepsis population (Keul et al., 2020). Pediatric and adult sepsis guidelines including the *Surviving Sepsis Campaign* create a culture of increased urgency and awareness for time-sensitive management of sepsis patients (Schorr, 2018). Applying these concepts to the neonatal population is reasonable considering the altered neonatal immune system capabilities, the unpredictability of illness onset, and clinical decline potential in this vulnerable neonatal population (Bissinger et al., 2013).

Market Analysis

Needs, Resources, and Sustainability

Patient care units planning to introduce quality improvement initiatives should employ a formal process to establish a need and justify resource allocation to such projects. Priority should be emphasized on initiatives that "address a quality gap of high magnitude and impact, have a high-likelihood of success, have a champion, fit with the unit's state of readiness for change, and have organizational support and align with organizational priorities" (Katakam & Suresh, 2017, p. 1161). Therefore, a formal needs' assessment was performed to validate clinical staff concerns for presence of the clinical problem. Permission to evaluate retrospective data was granted and the inconsistent administration of antibiotics on admission to the NICU was observed and confirmed.

Resources needed to complete this project are presented in the logic model found in Appendix F. Access to the electronic medical record (EMR) computerized provider order entry (CPOE) admission sepsis order sets specific to the NICU was required for modifications. Support from the pharmacy information technology (IT) specialists was also needed to explore and mitigate complex electronic systems inputs related to antibiotic orders. A pharmacy liaison key representative was established for this project.

The project timeframe may be reviewed in Appendix G. The project timeline experienced unexpected delays secondary to IT complications encountered while testing new inputs and applying it to practice at the bedside. Project initiation occurred in August 2021 and data collection was complete in March of 2022. Data analysis was completed in June of 2022. The initiation phase required eight weeks to complete all necessary staff surveys, create and disseminate neonatal sepsis education, communication of project goals and objectives, create excitement, and communicate preintervention benchmark data to staff. The novel SAM Admission Prioritization tool was implemented at this time as previously expected.

IT modifications required testing in the EMR test environment with simulated patients. Several historic workarounds in the aged EMR system were encountered and finding accurate historians knowledgeable of the original CPOE implementation elements proved challenging. However, key knowledge gaps were discovered, and mitigation specific to the EMR electronic ordering challenges was achieved by the end of December 2021 and the new CPOE order set was launched January 2022 following provider and pharmacy education on changes.

Because the DNP candidate actively functioned in an APRN provider role at the project site, there existed a reasonable cushion to capture staff who may have been on vacation or professional leave and provide availability to clarify any questions that arose after the initial education portion of the project implementation phase as well as reinforcement for process changes in real time.

During the education phase, the novel SAM Admission Prioritization Tool was included in the nursing education module and posted at the staff huddle communication board for frequent review (Appendix H). Each admission packet was supplied with the novel SAM Admission Prioritization Tool. The tool was added to an existing admission patient data collection form already used to decrease cost of additional paper.

Unit culture historically established the staff breakroom as a protected social reprieve and is not intended for use to disperse education materials. It was felt acceptable to the NICU nursing practice council that access to the QR codes for surveys would be useful there due to high rates of staff gatherings in this location. QR codes were also posted at the huddle board, each patient care pod, emails, and the unit staff texting app *Crew*.

The physical geography of the NICU consists of two large, isolated pods consisting of about 20 rooms on each pod or approximately 30-35 patient beds per pod. Each pod was provided copies of the SAM Admission Prioritization Tool and the short neonatal sepsis education piece to accommodate nursing physical locations during their scheduled shifts.

Initiation of data collection occurred immediately after the launch of the revised CPOE order set in January of 2022. The medical director holds the master copy of the order set and was activated immediately after testing was completed. Data collection occurred in real-time on a weekly basis as the activities surrounding the data outcomes are within 60 minutes from admission and were not impacted by patient length-of-stay. Nursing post surveys were collected in May 2022 in the same fashion as the presurvey process.

Sustainability of the primary outcome of this project is dependent on several factors. Addressing the ability to modify the electronic medical record computerized order entry system to trigger high priority orders to the pharmacist at all hours of the day is crucial. Additionally, sustainability is dependent on nursing staff and their ability to maintain buy-in for reprioritizing admission activities surround the NICU admission process with the use of the SAM tool and building their self-efficacy as essential advocate in neonatal sepsis. Adopting a uniform sense of urgency that creates a new sepsis management culture is necessary to persist through inevitable staff attrition over time. Ensuring the culture is carried forward as part of new hire onboarding process throughout all NICU nurse preceptors will be essential.

Stakeholders and Project Team

Several stakeholders maintain investment in the execution and success of this project. Internally, the clinical staff directly involved in the direct patient care of the infant and NICU nursing educator have a vested interest in timely and accurate management and treatment of neonatal EOS. The NICU nurse educator is responsible to initiate and establish process and practice changes to the NICU and historically is spread thin over additional units. The APRN Neonatal Nurse Practitioner is a unique role as a neonatal clinical expert that compliments the ongoing support for nursing knowledge development both as a consultant and active teacher at the bedside.

NICU nursing leadership and the medical director have a vested interest as they often lead unit initiatives and must speak to metrics that fall short of organizational goals to higher hospital administration. Maintaining a proactive approach to suspected clinical problems will be well-received by hospital administration members. Pharmacy leadership and pediatric pharmacy team members maintain high investment in all QI projects that improve pharmacy to clinical unit communication and mitigate delays or errors in medication administration to the patients. The project team organizational chart is presented in Appendix I.

As an organization, MercyOne Des Moines Medical Center is committed to providing safe, quality care to all patients and families and high value is placed on monitoring quality data to help evaluate and improve care delivery. The organization incorporates The Joint Commission's National Patient Safety Goals into practice and proactively seek new and innovative ways to provide the highest quality of care to those they serve (MercyOne, 2021).

The organization embraces a culture of antibiotic stewardship as well as a supportive culture for attentive and rapid management of possible sepsis cases as indicated by a hospital wide sepsis protocol and rapid response team for the adult and pediatric patients. The NICU has remained an isolated entity within a larger adult-focused institution which manages internal neonatal clinical crisis independently of hospital wide critical care response teams. The responsible use of antibiotics as well as a focus on ongoing quality improvement initiatives embodies high value.

Externally, expectant families often choose where they prefer to deliver their newborn. Patient satisfaction on overall communication and management of critical patient events travels within communities through word of mouth and social media. Additionally, financial donors often explore pediatric service lines as financial beneficiaries. Maintaining rapport with the community is essential for ongoing referrals and financial support for unit operational and capital funding needs (C. Murphy, personal communication, February 2, 2021). Finally, the patient is the ultimate stakeholder whose outcome may depend on prompt attention and management of suspected sepsis consistently for every patient encounter. There is nothing more valuable than treating a suspected critically ill patient successfully and restoring the mother-neonate dyad as quickly and safely as possible.

Strengths, Weaknesses, Opportunities, and Threats (SWOT)

A thorough SWOT analysis was reviewed to examine the strengths, weaknesses, opportunities, and threats related to this project and can be viewed in its entirety in Appendix J. Key strengths included organizational and unit level support for quality improvement initiatives. There is strong clinical and Regis University faculty mentorship in the design and implementation of this project. Additionally, preexisting problem recognition and degree of concern from key bedside nursing staff built a sense of urgency and buy-in for this project.

Weaknesses include limited time for multiple revisions to the novel SAM Admission Prioritization tool. Many QI initiatives apply PDSA (plan-do-study-act) cycles in process improvements, and it is acknowledged that this may be beneficial for the ongoing development of this tool. Unforeseen limits to the EMR continued to inhibit several desired alterations to the CPOE neonatal admission order set and further improvements and alterations may require higher organizational requests on a national level in the future. Ongoing limits exist in evaluating some pharmacy processes including the human elements of time tracking of the antibiotic dose once it is made and has left the intravenous medication compounding room and is tubed to the respective patient floor through the hospital wide pneumatic tube system. This organizational limitation is a known hiccup and while rare, occasionally necessitates the remaking and resending of medications hospital wide that may have gone missing in the pneumatic tube station system. Additional weaknesses included cultural disruption with an unforeseen organizational acquisition, large staff nursing attrition, and pharmacy and NICU leadership attrition.

Several opportunities exist with this project. The addition of the DNP student as the first practicing Neonatal Nurse Practitioner (NNP) within the provider group offers the only APRN on staff with the education and skill set to bolster ongoing multidisciplinary quality improvement initiatives. The only other master's degree prepared nurse leader is the NICU unit director who is a clinical nurse leader (CNL) with a strong background in outcomes-based clinical practice in the NICU (AACN, 2021). The APRN NNP role is an asset to both physician and nursing practice with an understanding of multiple systems functions that may impact process shortcomings. This project provided an avenue to teach prioritization over the previous utilization of a simple checklist approach to patient care admission activities with the novel SAM Admission Prioritization Tool. Prioritization is an acquired skill set and is often challenging to teach in high-acuity health care environments.

Sustainability

Several threats exist to postimplementation project sustainability. Nursing pre and post survey responses pose a threat to validate nursing perspectives. Care has been taking to mitigate this threat with strong a priori sample size estimates and early planning to provide ease of access for all staff whether they are present on or off campus. Despite this, nursing attrition may alter response group experience categories and this demographic data was added to pre and post surveys. Nursing resistance to process change is of concern. However, since the problem recognition is nurse-driven, this is considered a low threat yet should be acknowledged. Human change is difficult to consistently achieve in a short period of time and long-term change is likely more realistic when attempting to alter large group culture change. High patient census may impact nurse willingness to utilize the new tool due to perceived increased workload and possible perception of less time to modify their current practice routine. The SAM Admission

Prioritization Tool will re-prioritize tasks from an existing simple checklist and in its place group the admission into stages, decreasing the pressure on the bedside nurse to complete a single large checklist. Nurse staffing turnover rates presented a threat to sustain a culture of urgency surrounding neonatal early-onset sepsis management and the importance of the bedside nurse's role in patient advocacy and fluid execution of admission activities.

Cost-Benefit

Cost

Potential costs related to this project were considered prior to implementation. The project lead DNP student donated all time related to project activities. The cost of nursing participation is included in their usual required continuing education activities for unit education and are often completed during downtime while at work. Should nursing education need to happen off shift, the nurse may be honored this need and receive pay for their required education time. The average nursing wage is $25 per hour. Should 10% of the staff require this, the unit may need to invest about $2500 total. This was a modest overestimate of need. The nurses are usually honored a 60-minute education hour under these circumstances (R. Evans, personal communication, April 28, 2021). Nursing nonproductive wages were not required during this project.

The necessary pharmacy time is included in their usual project time required for their respective specialties. While not anticipated to occur, acknowledgement of the average pharmacist hourly pay is $60 per hour in this facility should time outside of usual work hours be required (D. Bass, personal communication, May 1, 2021). Pharmacy nonproductive education hours were not required during this project. Pharmacy and provider education will occur in usual routine mandatory monthly meetings. Minimal cost will be associated with creating paper copies of education modules for nurses and new laminated admission tools for each patient room from the NICU office supply availability.

Benefit

All neonates admitted to the NICU regardless of birth gestation or access type received the implemented process changes in which they may receive benefit from. Data was collected only on infants meeting predetermined inclusion criteria with peripheral access for the defined comparison groups. Additional benefits included a thorough systems analysis for all key components of the NICU admission process, providing nursing continuing education, and addressing needed improvements to the EMR for improved pharmacy communication. These interventions may overflow into other medical diagnosis, improving the care of subsequent infants over time. Disseminating knowledge of successful project implementation and sustainability may benefit other NICU's worldwide considering initiating a similar quality improvement initiative (see Appendix K).

Project Objectives

Mission

To identify and mitigate systems barriers and restructure nursing prioritization skills to ensure first dose antibiotic is infusion prior to 60 minutes from admission to the NICU.

Vision

All neonates admitted to the NICU will consistently receive first dose antibiotics prior to 60 minutes form admission.

Goal

The primary goal of this project was to improve the systems elements for the NICU admission process to ensure first antibiotic infusion time is under 60 minutes from the time of admission for neonates requiring evaluation and treatment EOS.

Objectives

1. To improve systems process elements surrounding the NICU admission process
   a. Improved communication through modified CPOE admission order set
   b. Measurement: modification of order set that prompts early recognition by pharmacy with improved order review timing in under 10 minutes

2. To improve nursing knowledge and patient advocacy related to newborn sepsis
   a. Nursing pre-survey, nursing education, nursing post-survey
   b. SAM Admission Prioritization Tool to support admission activities
   c. Measurement: improved confidence and knowledge on post-survey and improved documented clinical dosing weight entry time

3. To establish care equity in the neonatal population in the NICU equal to their pediatric and adult counterparts undergoing sepsis evaluations
   a. Increase the sense of urgency through education and standards of performance through established benchmark
   b. Measurement: Maintain robust order entry timing, improved pharmacy order review, and maintain swift IV placement timing by nursing staff

4. To improve antibiotic administration timing for neonates in less than 60 minutes from admission to the NICU as recommended by the National Institute for Health and Care Excellence
   a. All above elements to contribute to improved timing of first dose antibiotic infusion
   b. Measurement: Improved antibiotic infusion timing in under 60 minutes from admission

Evaluation Plan

Logic Model

The logic model presented below (see Figure F1 below, or Appendix F) is a visual representation of current inputs, constraints, and process changes required to meet the target outcome for antibiotic infusion prior to 60 minutes from admission to the NICU in neonates requiring sepsis evaluation and treatment. Key constraints in the current system include a delay in communication of dosing weight to pharmacy and an aged EMR that have required workarounds that changed order priority status' that allow for appropriate and consistent medication scanning at the bedside. Prior to the intervention, antibiotic priority status did not alert pharmacy of the pending urgent antibiotic request, causing a delay in order review by the pharmacist and subsequent initiation of antibiotic production by the pharmacy intravenous medication compounding room.

Nursing workload in the NICU allows for efficient admissions; however, nurses often have additional patients that require their attention due to usual staffing models in the NICU. It is not uncommon for the admission nurse, charge nurse, and surrounding nurses to have availability to assist an admission for up to 60 minutes before additional patient responsibilities are required (A. Hamilton, personal communication, February 2, 2021).

To achieve the primary outcome for improved first antibiotic timing, several process inputs must be improved, reinforced, and sustained. Providers must maintain timely order entry practices. The existing EMR requires updates to improve antibiotic priority status with the inclusion of pertinent patient data for dose-range checking by pharmacy. Finally, nursing staff must prioritize admission activities during the admission process to include prompt documentation of the clinical weight, establishing early peripheral intravenous access, and initiating antibiotic therapy within the recommended 60-minute timeframe from admission. This model shows the complex system interdependence between provider, pharmacy, and nursing workflows that have necessary roles to achieve timely antibiotic infusion prior to 60 minutes from admission to the NICU.

The inputs required for the success of this project are intended to improve system flow without the need for new or additional tasks in the current NICU admission process. These inputs included restructuring the admission order set to change the priority stamp on antibiotics to alert the pharmacist of the pending order without the extra workload of phone calls or pages.

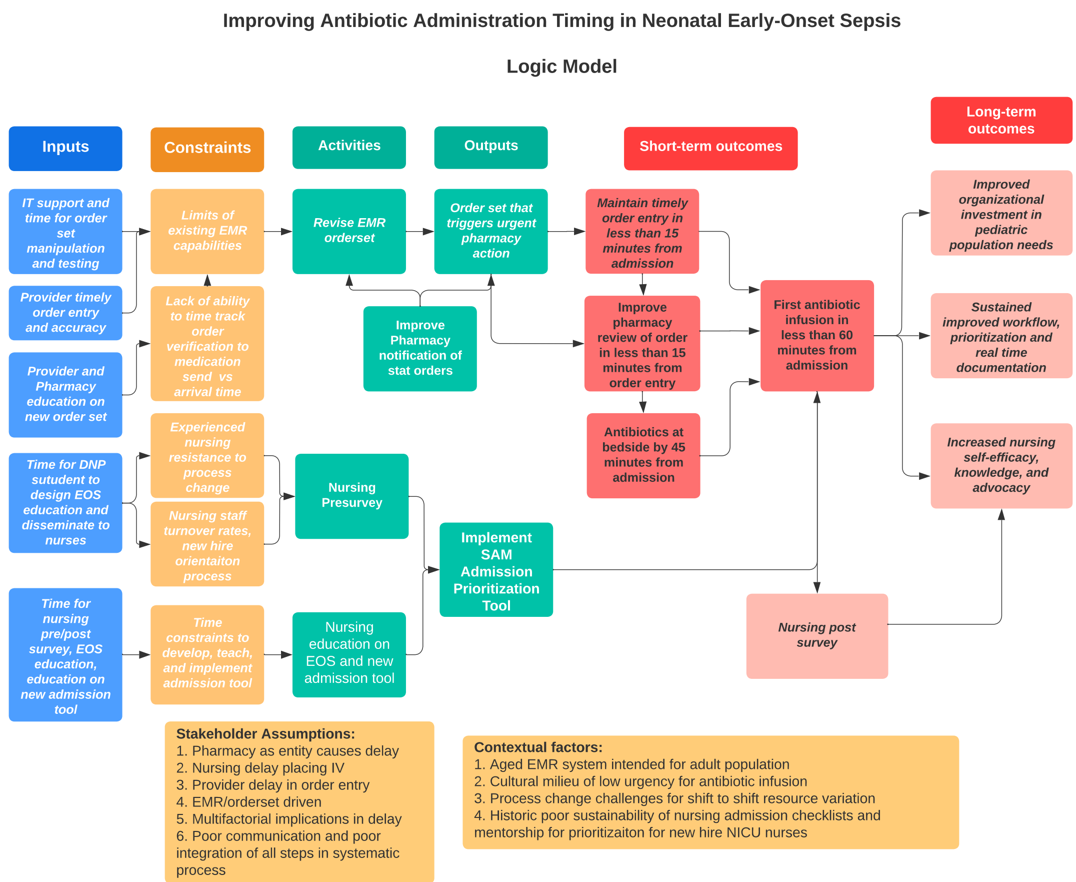
A short nursing continuing education piece was provided as part of routine periodic staff nursing education. Introduction of a novel admission prioritization tool entitled ‘SAM’ for stabilize, activities, and maintain, is intended to restructure thinking around the usual tasks surrounding the admission towards one of prioritization of an ill newborn requiring stabilization and models the usual golden hour concepts applied to preterm infants.

SAM Admission Prioritization Tool

The SAM Admission Prioritization Tool has been created for the purpose of this project by the DNP student and has not been used previously nor was it previously validated to increase the nurse’s ability to learn prioritization skills (see Appendix H). Wide variation exists in the approach to NICU admission activities and depending on nursing team configuration results in inconsistent teaching and execution of critical time-sensitive activities surrounding the NICU admission. The usual checklist approach may be overwhelming and difficult to envision a process or workflow. This tool is intended to be utilized as a teaching and training resource for new hire NICU nurses and experienced NICU nursing staff to assist in the ongoing skill development for the bedside nurse during high-stress and high-anxiety producing activities such as neonatal NICU admission.

Figure F1

Logic Model: Improving Antibiotic Timing



Note: Logic model for project inputs, constraints, and benchmarks to meet primary outcome for antibiotic infusion within 60 minutes from admission to NICU.

Project Methodology

This design of this project is a pre/post intervention quality improvement initiative that included a mixed methods approach. The proposed outcomes included patient-sensitive outcomes for improved antibiotic infusion timing, nurse-sensitive outcomes with increased knowledge and self-efficacy surrounding neonatal early-onset sepsis, and organizational sensitive outcomes maintaining awareness and commitment for the organizational antibiotic stewardship culture. Group performance evaluation at baseline included nurses, pharmacists and providers on any given day staffing the NICU. Patient characteristics will vary in their gender and gestational age, but all subjects will maintain the same diagnosis of early onset sepsis evaluation with peripheral vascular access and antibiotic orders on admission to the NICU.

Independent Variables

The intervention includes independent variables encompassing a revised electronic NICU admission order set with new inputs for providers and escalated antibiotic priority status to prompt pharmacy review. Implementation of a novel nursing admission prioritization tool is intended to improve nursing workflow and prioritization for critical admission activities including establishing peripheral access and early communication and follow-up on antibiotic availability for timely infusion. Nursing and pharmacy education was provided to increase knowledge and self-efficacy related to the NICU sepsis admission.

Dependent Variables

Dependent variables include the primary outcome of documented antibiotic infusion time at less than 60 minutes from admission to the NICU. Additional dependent variables included order entry timing for benchmark data, pharmacy review of order time, and peripheral intravenous access placement time by the bedside nurse for benchmark data. Presumptions surrounding order entry timing and nursing skill at placing peripheral access quickly required validation through data collection. Documentation of the neonate’s clinical dosing weight is time sensitive information as the dosing weight is required by both providers and pharmacy for order placement and verification. All dependent variables were evaluated for improvement or sustainment. Nursing self-efficacy and knowledge was measured through the utilization of pre and post intervention surveys.

Patient sensitive data collection included time stamped events already documented in the patient chart as part of their usual care and is readily available for pre and postintervention analysis. Data collection forms have been created and a context specific database for both patient and nursing data are shown in Appendix L, Table L1 and Table L2.

Providers utilized a revised electronic NICU admission CPOE electronic order set and received a short education session during a routine provider meeting prior to implementation as well as one-on-one coaching. The provider group is small, consisting of nine providers and education was efficient with a live demonstration of the updated CPOE electronic order set. Reinforcement was required throughout the project due to the natural evolution of new habit creation as some of the required elements were dependent on voluntary inputs versus electronic automation.

Pharmacy did not require additional tasks for their usual workflow. The changes are anticipated to decrease their usual tasks of finding a patient clinical dosing weight and frequent scanning their order que for new orders as this should be automated by the project design. Pharmacy staff were also provided a short education on the updated CPOE electronic order set and notification process.

Evaluation of nursing staff knowledge and confidence

A pre- and postintervention nursing survey utilizing a Likert-type scale was utilized to evaluate confidence and knowledge base surrounding the NICU admission milieu (Appendix M). The surveys were tested prior to distribution for questions interpretation, understanding, and reliability amongst the unit nursing shared governance team (Terry, 2018). Questions were close-ended, and answers were scaled to provide quantitative data suitable for statistical evaluation (Polit, 2010). While some differences will exist in which nurses complete the pre- and post-surveys, all nurses will receive the same education prior to the intervention phase. With the need for a high response rate, many of the same nurses were post-intervention respondents, increasing validity and reliability of responses for comparison between these dependent groups (Hollingworth & Collins, 2011; Polit, 2010).

A four-point versus a five-point Likert-type scale was chosen to avoid an over response of neutral with the intention to achieve a better understanding of nurses' current knowledge and self-efficacy in participating in a NICU admission (Losby and Wetmore, 2012). To improve distribution and access to surveys, survey links were emailed and sent through an established text messaging process to the nursing staff. For additional ease of access, a QR code will be created for the survey link and posted throughout the NICU on both campus sites. Daily reminders occurred during shift change huddles as part of a usual huddle script to complete the surveys.

After completion of the presurvey, a short nursing education module was provided on neonatal early-onset sepsis as part of the implementation plan of the SAM Admission Prioritization Tool that was designed to streamline admission activities and strengthen nursing self-efficacy for task prioritization at the bedside. Education on neonatal early-onset sepsis and the novel SAM admission tool was provided in a single nursing activity. New hire nursing staff was provided the information during their onboarding as part of their training. A post-survey was collected after completion of the intervention to evaluate knowledge gained and level of perceived self-efficacy on the NICU admission process. The nursing education and SAM tool is intended to provide and reinforce foundational knowledge and the necessary tools to correctly prioritize admission tasks to improve patient outcomes. This includes maintaining acute awareness on time sensitive admission activities including urgent documentation of the clinical dosing weight, patient monitoring and stabilization activities, peripheral vascular access placement, and infusion of first dose antibiotic by 60 minutes of admission to the NICU.

Data collection

Following implementation of intervention activities, prospective data collection began within two weeks after implementation of the final step of the new CPOE electronic order set and continued for three months to meet necessary patient population numbers for adequate power. While the retrospective data comprised of a systematic sampling methodology, the prospective data was inclusive for all admissions to the NICU that met inclusion criteria of prescribed antibiotics for the admission diagnosis for rule out sepsis with peripheral intravascular access.

Neonates included met the expected gestational age criteria of greater than or equal to 30-weeks' gestation at birth, were inborn, and did not require a central line placement during their admission process. Many infants under 30-weeks' gestation are at risk for needing advanced respiratory support and central access. Neonates that were outborn or transported into the NICU from outside centers will be excluded as many of these neonates have received antibiotics in the field as part of their time sensitive care management during transfer.

Sustainability

To ensure sustainability for the investment in the project, data will be collected again at six months post-intervention and again at one-year post-intervention to observe for any new process constraints or clinical practice drift. This post-intervention analysis occurred after completion of the planned project timeline. The ongoing teaching on neonatal early-onset sepsis and the utilization of the SAM Admission Prioritization Tool will be emphasized during all future admission as well as onboarding and orientation of new hire nurses to the NICU beyond the scope of this project.

Protection of Human Subjects

Neonates are considered a vulnerable population. This project posed minimal risk to patients due to the lack of experimental design and lack of any new patient intervention that is not already considered usual care for their required evaluation and care for sepsis. Due to the nature of quality improvement, all neonates qualify for this practice improvement, process change, and evaluation. The greatest risk to the investigational patient groups was unintentional exposure of patient identity during collection and reporting of retrieved data.

Patient demographics including date of birth and medical record numbers were needed to evaluate and collect existing patient data to illustrate outcomes. To protect the patient, a unique patient identifier was used to link the medical record number separate from the data collection tool. Should a data transcription error be encountered, and review of the chart needed for data quality assurance, the patient identifier would be necessary to trace the data to the patient chart.

Staff surveys were accessible through personal email, text messages, and QR codes posted around the NICU to avoid any identified participation from peers or unit leadership. Open encouragement of participation did occur however to validate desired nursing input and recognition of the clinical problem. The nature of the questions helped establish evaluation of current knowledge and confidence and provided the project team valuable insight for a knowledge gap analysis across all nursing experience levels. The identity of those who complete the survey will remain completely anonymous. Access to survey results is only available through the DNP student's sign-on credentials with the Survey Monkey website.

The DNP candidate project lead completed the necessary Regis University institutional and local organizational IRB protecting human subjects in research education Collaborative Institutional Training Initiative (CITI) Program modules prior to project implementation. Local organizational IRB requirements for quality improvement initiatives were reviewed with the local IRB coordinator including the established required language needed within the local IRB QI project application with the intention for publication of project results (Appendix N). The DNP student remains current on local standards and requirements and maintains access to the local IRB system to pursue project approvals and updates when appropriate for this project. The unit medical director provided a letter of support for this quality improvement initiative (Appendix N).

Participation in quality improvement (QI) activities may be considered an organizational ethical responsibility. Acute awareness of current standard of care recommendations and evidence-based practices require organizations to have and maintain awareness of their current benchmarks and modifying those that no longer meet the recommended standards of practice. Quality improvement measures should be integrated in routine clinical practice, and regular review of data should guide practice improvements. QI culture and safety practices prove to be an effective approach towards improving clinical outcomes throughout the United States health care systems and are instrumental in creating an overall organizational culture of safety (Lynn et al., 2007).

Outcome Analysis Plan

Outcome analysis for this project included quantitative data collected to determine mean time from admission to the NICU to first antibiotic infusion time in the neonate requiring evaluation for early-onset sepsis. The primary outcome for investigation includes administration of first antibiotic prior to or at 60 minutes from admission to the NICU. Additional outcome measure analysis included mean time analysis of nursing documentation of clinical dosing weight, provider order entry timing, pharmacy review of order timing, and nursing peripheral access placement timing as critical time stamps during the admission process worthy of investigation and improvement to achieve the stated primary outcome. Nursing self-efficacy and knowledge surrounding neonatal early-onset sepsis and the NICU admission process was explored, and quantitative and qualitative data was collected through pre and post intervention nursing surveys. Nursing as a role in care coordination and patient advocacy is central to the success and sustainment of the primary outcome measure.

Patient Data Analysis

The patient specific primary outcome included documentation of first antibiotic infusion on or before 60 minutes from admission to the NICU. Under the circumstances a newborn is admitted directly from the delivery room and the admission time is unavailable, the birth time will be utilized as the start time benchmark. Newborns admitted from newborn nursery required an admission time to define a decision to treat timeline.

Descriptive statistics using a paired *t*-test was performed on all five outcome measures before and after the implementation of admission bundle items. The documented time data is interval in nature and is readily available in the hospital electronic medical record (Appendix L, Table L1). The mean times were be compared for improvement with statistical significance. Frequency data was also explored where appropriate to add meaning. Two-tailed paired *t*-testing was utilized in the SPSS software to analyze results (Ai-Therapy Statistics, 2021). The null hypothesis H_0 states there is no statistical difference between groups pre and post intervention, and the alternative hypothesis H_A is that the postintervention antibiotic timing will be less than or equal to 60 minutes, showing a statistically significant improvement between groups (Kuramoto, n.d)

A power analysis performed using the Ai-Therapy Statistics power analysis tool and G*Power power analysis tool confirmed a priori sample size estimates. This was additionally confirmed with the SPSS software (Appendix O). The estimated sample size needed for mean comparison of independent groups for a *t*-test with a power of 0.80, alpha of 0.05, effect size 0.5, and a confidence interval of 95%, 64 patients in each group were required (Faul et al., 2009). This sample size was achievable with the previous organizational needs' assessment. Systematically sampling of the NICU census over a six-month time interval was performed lending review of 57% of the NICU population at that time, providing a cohort of 52 patients that were prescribed antibiotics on admission to the NICU. Had all patients been included, an estimated 74 patients would have likely been available. Fluctuating unit census is a strong consideration in the sample size estimates. The NICU experienced a lower-than-average census during the need's assessment sampling, increasing confidence the a priori sample size estimates are adequate.

Nursing Data Analysis

The NICU historically employs approximately 100 nurses that provide primary bedside patient care (R. Evans, personal communication, February 1, 2021). Nonparametric data will be collected (Appendix L, Table L2). Descriptive statistics with the independent *t*-test for two dependent groups will be utilized to evaluate survey results due to the increased sample size needed and will surpass the usual Wilcox Mann Whitney *U* Test capability (Polit, 2010). The same group of NICU nurses will be offered the before and after intervention survey. The *t*-test will be applied to the matched questions that are the same on both surveys to evaluate difference in means between groups. Some survey questions are unique to before and after intervention implementation and will serve as investigation for long-term sustainability of this project (Faul et al., 2009).

The null hypothesis H_0 states there is no difference between groups where the alternative hypothesis H_A states there is a difference between groups of nurses after the intervention. A paired *t*-test analysis of increased self-efficacy and knowledge related to the NICU admission process will be performed with the assumption of improvement post-intervention (Ai-Therapy Statistics, 2021; Kuramoto, n.d.). An estimated sample size of 34 pre and post surveys are needed to achieve a power of 0.80, alpha of 0.05, effect size 0.5, and a confidence interval 95%. This was confirmed with SPSS software (Faul et al., 2009) (see Appendix O).

Inferential statistics will additionally be applied to extrapolate correlation information between years of nursing experience and confidence and knowledge surrounding the NICU admission process. The use of the Pearsons's *r* correlation was utilized to evaluate for linear correlation between variables. The information obtained may reinforce continuing staff education as a necessary activity for improved self-efficacy and knowledge over time regardless of years of nursing experience (Laerd Statistics, 2018). The null hypothesis H_0 states there is no relationship between years of experience with increased knowledge and confidence. The alternative hypothesis H_A assumes there is a relationship between years of nursing experience and increased self-efficacy and knowledge surrounding the admission process. Therefore, two approaches to data evaluation were performed from the same nursing data samples collected.

Presentation of Project Findings

Project findings included both preintervention baseline data and postintervention outcome data. Line graphs, pie charts and boxplots were be utilized to present pre and post data to include the dependent variables measured in time from the documented time of admission to the NICU and nursing survey data with years of experience demographics. Clear demarcation of the intervention time point was provided where applicable.

Patient chart variables including documented clinical weight, provider order entry time, pharmacy order review time, peripheral vascular access time, and first antibiotic infusion time were measured in minutes from admission time or if needed from birth time as previously determined. A single run chart line graph for each dependent variable by month were presented in minutes from admission on the y-axis and case patient on the x-axis to demonstrate improvement in variables over time. These charts proved useful for the review of initial interval data and provided a visual representation of the data distribution prior to application of the intervention (Polit, 2010). Pie charts provided better visual representation of provider order entry time trends.

Nursing survey ordinal data was represented in the form of bar graphs to demonstrate frequencies in percentile for improvement in confidence and knowledge before and after intervention. All matched questions in the pre and post nursing surveys were represented in side-by-side color coded bars for before and after intervention frequencies developed from the Survey Monkey website. Non-matched questions unique to respective surveys were presented in separate bar graphs for both before and after intervention questions representing explored information gathered on the nursing staff population. Themes developed from narrative feedback were presented in a list in order of frequency discovered. Correlation data was presented in chart form summaries. Cronbach's alpha was applied to survey questions.

Validity and Reliability

Validity of collected data through transcription errors of patient information to data collection tools may produce inaccuracies in statistical baseline and improvement calculations.

Validity of statistical conclusions will be assured through obtaining an appropriate sample size as determined a priori through the previously stated power analysis. Attrition or mortality are unlikely risks as the majority of the inclusion infants are low risk for mortality and will likely survive through 60 minutes from decision to treat. If a subject should expire, they were likely ill enough for central access and would not qualify for analysis based off predetermined project inclusion criteria.

Data quality monitoring will be performed on every tenth patient during data collection to ensure data transcription accuracy and will be trained prior to data collection. Data errors will not be accepted, and should an error be encountered, the previous ten patients' data will be reviewed. This interval is chosen due to the ease of reviewing ten patients as opposed to a larger interval and sample during the projected short project timeline should an error be encountered. The reliability of the second look data collection is high, as the data collected is already present in the chart regardless of the individual or timing of collection of the data.

Data transcription is also a risk for pharmacy system data collection. A review of the pharmacy data will also be performed with a defined sequential system to ensure data transcription accuracy by a separate pharmacist during data collection phases is performed. While unusual, the possibility of missing data from the EMR could occur and if encountered the subject will be not included for data analysis.

SAM Admission Prioritization Tool

The novel SAM admission prioritization tool is in its second formal revision following the postsurvey feedback (see Appendix H). The tool was created by the DNP candidate and developed and revised with collaboration from the unit nurse educator, nurse preceptors, staff nurses, nursing shared governance members. The DNP candidate has previous experience and expertise in the nurse educator role and in agreement from key nurse staff stakeholders hold similar views regarding difficulties teaching prioritization and triage skills in a critical care environment.

During the project proposal phase, it was suggested by Regis University nursing faculty to increase validity of this tool by dispersing it to a similar NICU for independent use and review. The project team felt widely dispersing the document in its infancy without any clinical use was not ideal and opted to use and refine the document over the first couple months implementation internally. It was formally sent to the Iowa Association of Neonatal Nurses leadership for feedback as representatives from multiple NICUs statewide.

Conceptually, the novel SAM tool embraces the Golden Hour concept adopted from the adult trauma arena that has been applied to the preterm neonate population. Golden hour interventions have been shown to impact both short and long-term outcomes for all populations of neonates by the use of evidence-based interventions (Sharma, 2017). The tool additionally encompasses major concepts taught by the STABLE program (Karlsen, 2006). These are important stabilization interventions for all key stakeholders involved in neonatal care and using tools to reinforce this knowledge and practice culture is optimal. The members of IANN that reviewed the tool felt it was well organized and provided direction and prioritization, clearly communicated site specific NICU culture and expectations, served as a useful handoff tool when indicated due to time stamping sections, and reinforced the importance incorporating knowledge and culture from the Golden Hour and STABLE concepts as part of the tool for ongoing professional staff development (E. Spellman, personal communication, June 28, 2022; K. Steffen, personal communication, June 30, 2022).

Nursing Survey Data

Reliability of the nursing survey results are a potential risk during the project. To minimize this risk, a four-point Likert-type scale was used to drive true opinion and avoid neutral ground for answers (Losby & Wetmore, 2012). Surveys completion in their entirety was required and estimated time to completion was at less than three minutes (SurveyMonkey, 2021). Due to the high number of surveys required, many of the same nurses completing the presurvey will be completing the postsurvey, increasing reliability of the assessment of postintervention improvement measurements. To increase nurse to nurse reliability in responses, surveys were pretested on a small group of nurses prior to use to ensure questions were understood, intended measurements of answers were obtained, and subject to subject dependability of answers were demonstrated (Terry, 2018). Nursing staff attrition is possible in this project; however, the needed number of pre-and post-surveys is relatively high and are the same staff nurses that were offered the pre-survey.

Project Findings and Results

Description of the Patient Sample

Demographic data including birth gestation and birth weight were used to describe categories of patients which is usual practice in this population. This data could be considered nominal or ordinal due to the hierarchy to the information. Over 200 patient charts were reviewed pre and post intervention. Patient gestational age at birth was stratified into usual descriptive categories of term (>39 weeks birth gestation), early-term (37 0/7-38 6/7 weeks birth gestation), late-preterm (34 0/7 weeks-36 6/7 weeks birth gestation), and preterm infants under 33 6/7 weeks gestation. Other categories of patients have been described in the literature including moderate preterm infants with differing definitions and extremely low gestational age infants (ELGAN). The World Health Organization defines moderate preterm infants as 32-34 completed weeks, very preterm as 28-31 completed weeks, and extremely preterm infants as less than 28 completed weeks, differing slightly from other published categories including the Centers for Disease Control and Prevention (CDC) and the March of Dimes organization. All groups are consistent in describing preterm infants as all infants born prior to 37 0/7 weeks gestation at birth (World Health Organization, 2022; Centers for Disease Control and prevention, 2021; March of Dimes, 2022).

Neonatal weight categories at birth were also described including low birth weight infants (LBW, $\leq$ 2500 grams birth weight), very low birth weight infants (VLBW, $\leq$ 1500 grams birth weight, and extremely low birth weight (ELBW, $\leq$ 1000 grams birth weight). Large for gestational age infants (LGA) were specifically defined as those that were macrosomic > 4000 grams birth weight due to unique risk factors for this categorized group. Usual definition of this group is birth weight over the 90^{th} percentile for their birth gestation. The LBW infant if of particular importance due to known risk factors for sequelae following birth and often correlate with the LPT infant category. Other categories that were not described include subcategories of appropriate for gestation weight (AGA, between 10-90% percentile), small for gestational age (SGA, $\leq 10^{th}$ percentile), or large for gestational age (LGA, $\geq 90^{th}$ percentile) due to overcounting infants already defined by birth weight and birth gestation but is acknowledged as important demographic information in the clinical care environment. Congruent with the literature review, the late preterm and low birth weight (birth weight less than or equal to 2500 grams) populations accounted for the highest proportion of NICU admissions at the study site accounting for over 50-60% of the admission population both pre and post intervention (Table P1, Appendix P).

Statistical Tests Performed (SPSS)

A paired sample *t*-test was performed on the before and after patient data to compare means for statistical significance in improvement for all steps in the process as an aggregate as well as each step individually as a pair to help identify delay with any step in the process.

Aggregate Process

As an aggregate process, the five outcome measures must occur sequentially in overlapping steps within the 60 minutes from decision to treat. Pre and post intervention independent groups were compared with a paired *t*-test. There was a statistically significant improvement ($p<.001$) for the combined sequential process of the aggregate essential steps following the intervention.

Clinical Dosing Weight

The time sensitive nursing documentation of the neonate's birth weight as the clinical dosing weight was an initially overlooked step in project planning. During the testing phase of the CPOE changes, it was revealed that pharmacy cannot process orders without an entered clinical dosing weight on the nursing side. There exists institution to institution variation on role responsibility for entry of this critical patient data. This discovery prompted additional data point review, revision of the SAM prioritization tool, and urgent additional nursing education. Upon data review, the time lapse for documentation of this critical patient data was extraordinary and at times over 8 hours after admission or in some cases never documented. Historic workarounds for this step required pharmacy to call nursing to find out the weight that was inconsistently entered in the patient chart.

The current EMR system design communicates a documented clinical dosing weight to the pharmacy electronic system; yet this step has been notoriously confusing to bedside nursing staff since the launch of the EMR in 2010 due to several prompts for weight entry in different locations of the patient chart requiring triple charting (A. Hamilton, personal communication, October 5, 2021). Following additional nursing education there was an increase in consistent documentation of the clinical weight, however there remained several outliers and some patients continued to not have the information documented, but the incidence was less. The improvement in data points was statistically significant (p=.029) and visual representation of data can be review in Appendix P, Figure P1.

There was a decrease in mean documentation time from 56.52 minutes to 31.54 minutes; an improvement of 24.986 minutes. For this data analysis, there is meaning in a true zero. Due to missing data, nine zeros were entered into SPSS as place fillers for final data analysis. Conceptually, missing data represented the task never occurred and zero indicates exemplary performance. Because the placeholders did not skew the statistical significance, review of overall mean to determine a placeholder was not necessary. Analyzing the data without the outliers may better represent the true mean without changing the statistical significance of the performance change from pre to post intervention. Regardless of the pre and post intervention means observed, both remain unacceptable mean documentation times of this critical patient information. Properly representing the mean is essential to not over or underestimate the power of the reasons behind the change. This was an extraordinary accomplishment for the nursing staff as they embraced their potential impact on patient care through their clinical performance.

Provider Order Entry

There is a lack of existing unit benchmark performance data related to this variable. In discussion with the medical director, it was estimated that a ten-minute window to write patient orders would be desired. Pre and post data revealed through descriptive data that modes fell between 10 and 15 minutes of admission. The NICU is a high acuity environment, and the unit culture is usually one provider performing the admission decisions and completing orders. If multiple admissions occur within a short timeframe, during rounding hours, or nursing shift change, there is potential for longer than average order entry timing secondary to patient care needs. The expected outcome included insight into provider workflow without statistically significant differences pre and post intervention. Paired *t*-test showed no statistical difference between groups (p=.382). There was however improvement in overall distribution of order entry timing despite the addition of novice providers new to writing admission orders during the implementation phase of the project, likely reflecting an improved sense of urgency. Mean order entry time dropped from 12.07 minutes to 10.39 minutes, a decrease of 1.691 minutes (Figure P3, Appendix P).

Pharmacy Review of Orders

Clinical pharmacists monitor an order cue for new patient orders and are required to review orders in a specified timeframe depending on order priority. Preintervention, antibiotics were designated as routine in nature, did not populate top of pharmacy cue, and required a 30-minute review window. Previous attempts at STAT order priority status were unsuccessful with varied historic knowledge for reasoning behind this complication. Several workarounds had occurred in the previous 12 years, leading to an overall decreased sense of urgency as a process. Changing orders to a STAT priority status was not simple as this triggered IT requirements for a different order entry process by the provider that is not automated. First-dose antibiotic is weight-based and historically a weight is entered, and pharmacy applies the usual 100 mg/kg ampicillin dose to this weight, rounding to the nearest five milligram due to standard drug concentration. Under a STAT priority, this process does not allow for appropriate scanning of the medication at the bedside as there existed a background IT task conflicted with current dose and did not link the two elements of the order. This complication is resolved if the ordering provider applies the clinical dosing weight and designates a final dose in the original electronic order. Several months of research and locating the correct pharmacy IT historians was required to discover this solution.

Additional complications included a short time interval of 30 minutes to scan the medication at the bedside that was also mitigated in the background to 60 minutes. The nursing staff was educated that they are only able to scan the medication up to 60 minutes following order placement, also creating a sense of urgency. Under routine order status, staff was able to scan the medications regardless of timing and override alerts and documented reasons for a late mediation scan. Following pharmacy, provider, and nursing education, utilization of this process became more frequent.

Despite time required for human change, the STAT order priority required pharmacy to review orders in 10 minutes, as opposed to the previous 30 minutes, and the order now populated the top of the order cue. There was a statistically significant improvement of pharmacy review of orders (p<.001) with a decrease in mean time of 13.58 minutes from a mean of 24.55 minutes to 10.97 minutes post intervention.

Nursing Peripheral Access Placement

NICU nursing skill at peripheral access placement is historically excellent. Unit benchmark data was established by monitoring pre and postintervention peripheral access placement timing as a potential cause of delay for first dose antibiotic infusion and was not anticipated to have significant impact on primary outcome. This vulnerable population is at risk for hypoglycemia shortly after birth or admission to the NICU related to the inability to feed by mouth related to the degree of prematurity present, existence of respiratory distress, or other clinical factors. These infants require continuous dextrose infusion and therefore the degree of urgency is usually related to initiating glucose infusion support quickly versus the intent for antibiotics for this population. Pre intervention mean peripheral access placement occurred in 20.74 minutes, with a decrease of 4.1 minutes in the post intervention group to 16.64 minutes (Figure P4, Appendix P). While not statistically significant (p=.091), this was important maintenance of skill and demonstration of urgency in the aggregate process which may have been impacted by nursing attrition and increase of agency and new graduate nursing staff during the intervention phase. It should be acknowledged there may have been some degree of the Hawthorne effect as nursing staff was aware of active data collection this data during this timeframe.

First Dose Antibiotic

The primary outcome for antibiotic infusion timing was statistically significant in improvement (p<.001) with a decline in mean time from 91.61 minutes to 67.25 minutes (Figure P5, Appendix P). In review of the established PICO, the intended outcome stated neonates would receive first dose antibiotic in 60 minutes or less *more often* than preintervention. While mean time significantly improved, the post mean is 67.25 minutes. There are upper time outliers that are potentially skewing this post mean result. Review of the frequency tables for pre and post intervention antibiotic infusion times reveal only 22 of 79 patients preintervention received first dose antibiotic in 60 minutes or less (27.8%) and postintervention 37 of 69 patients received first dose antibiotic in 60 minutes or less (53.6%), reinforcing success in the ‘more often’ portion of the PICO statement and a mean improvement of 24.362 minutes in the overall administration timing (Appendix Q). It is crucial to not overestimate the statistical significance and continue ongoing review of the process changes for undiscovered human elements that may continue to impact the primary outcome. There remains much room for improvement in the refined process that may only be explained by human factors, some of which was captured in the post nursing survey.

There are several pharmacy human factors that do not have time stamps including the time required to create stock solutions for ampicillin twice daily, the preparation of first dose in the intravenous compounding room, the process of the medication check by a pharmacist in the main pharmacy, and ultimately the delivery of the medication through the hospital wide pneumatic tube system. This project focused on improving current primary key systems process elements first without creating new roles or an increase in budget for extra staff. A secondary evaluation of obscure human elements through time studies is warranted in the setting of the current success of 53% of the population achieving the primary outcome.

Pearson's Correlation

Pearson's *r* was applied to evaluate for correlations. There exists a statistically significant low positive correlation (r=.306, p=.011) between post intervention pharmacy review of orders and post antibiotic timing indicating the longer the time span to review orders, first dose antibiotic time was delayed. There was a statistically significant moderate positive correlation (r=.401, p<.001) between post intervention order entry timing and post antibiotic infusion timing reinforcing prompt order entry impacting antibiotic infusion times (Table P2, Appendix P). Two additional correlations were discovered from the data that after review did not have real world clinical application and are not reported here.

Description of Nursing Population

The MercyOne William and Josephine Norkaitis NICU is located in Des Moines, Iowa and is a 42-patient room level three NICU housing approximately 64 patient beds with the ability for modest expansion based on revolving census. Historic nurse staffing numbers included 100-130 staff registered nurses (RNs), four to six nursing managers, charge nurse staff, internal NICU PICC team, a NICU dedicated lactation team, and a neonatal transport team. Historic annual hiring trends have increased over the last seven years from about eight nurses annually to over fifteen.

Unit nurse staffing shortages at the study site, like many inpatient units across the country, is at their all-time low due to the SARS COVID-19 pandemic and projected nursing shortages that existed prior to the pandemic (American Nurses Association (ANA), n.d.). The United States Bureau of Labor Statistics projects nearly 200,000 annual openings for registered nurses between 2020 and 2030 with a current median age of RNs at 52 years approaching retirement, outpacing replacement workforce both at the bedside and as nurse educators (ANA, n.d.). This shortage affects intake of prospective students, and more than 80,000 applicants were turned down in 2021 due to faculty shortages, lack of clinical placement ability, and supportive resources according to the American Association of Colleges of Nursing (AACN) (Husic, 2021). This NICU site is not immune nor exempt from the current nurse staffing trends and challenges related to the present nursing workforce climate.

Active nursing attrition, unexpected loss of unit nursing leadership, increased agency staffing, and increased new hire RNs actively occurred during this project. Nursing post survey results related to years of experience was especially concerning secondary to the distribution of reported experience. Postintervention there was respondent rate of 56 of approximately 88 nurses remaining, a response rate of 63.6% of the existing core nursing staff. In review of the Survey Monkey graph for this question, there reveals a loss of nursing staff over ten years of experience and influx of under two years of experience. Of particular interest was the loss of responses in the two-to-five-year range of experience. Actual staffing numbers reported by the interim NICU nursing directed is 88 nurses on staff and she confirms a loss of this group of nursing experience (A. Hamilton, personal communication, July 2002).

This is an important finding to report to unit and organizational leadership as this group of nurses consists of trained and highly functioning bedside nursing staff often viewed as the succession and staffing stability plan in this unit. These nurses are often recruited to the charge nurse role, transport team, PICC team and serve as nursing student and new hire mentors. Efforts to explore this specific staffing population for retention would be worth investigating (Figure R1, Appendix R). Additionally, 30 of the 88 core nurses, or 34% of core staff nurses, are pro re nata (PRN) status and work as they desire and do not in essence support guaranteed FTE staffing coverage needs.

Statistical testing performed (SPSS):

Nursing data included descriptive statistics with nonparametric data. The survey question data was first separated out to match appropriate scale as to not skew results and provide accurate analysis of obtained data. All questions of ordinal Likert-type scale were placed as a cohort together and run through a paired sample *t*-test as an aggregate and then paired t-test for each individual matched question with SPSS software. These questions were then analyzed for statistical significance. Pearson's correlation was obtained on all nursing data assuming linear and directional correlations. One nursing knowledge survey question was separated and analyzed separately out due to nature of scaling for accurate analysis.

Survey Aggregate Results

Results of the survey as an aggregate were not statistically significant following intervention (*p*=.697). There was a significant nurse attrition during this project, and it is estimated based on the survey results revealing experience that the increase in new hire nursing may impact this result. All mean scores dropped including nursing years of experience, however mean scores related to desire for the SAM admission prioritization tool increased (Figure R2, Appendix R).

Nursing Confidence and Self-Efficacy

The NICU is a complex high acuity environment encompassing patients requiring critical care, medical-surgical care, cardiac care, chronic care, and palliative or hospice care. It is not uncommon for experienced staff mentors to ask their colleagues if they are feeling overwhelmed or if they feel comfortable with a clinical situation. Therefore, these were the terms chosen for the survey due the frequency of use in this specific environment. While mean scores for feelings of discomfort and feeling overwhelmed decreased implying increased discomfort and feelings of being overwhelmed, mean years of nursing experience also declined, which would be expected despite the provided education module (Figure R2, Appendix R).

Nursing Knowledge Questions

Antibiotic Timing. The presurvey tested nursing knowledge related to antibiotic timing and was evaluated again following the nursing education module. While the mean scores decreased, there was a statistically significant improvement in knowledge following the educational intervention (*p*=.038). This question was a multiple-choice question with antibiotic timing options. When reviewing the answers, the bar graph reveals an important implied increased sense of urgency. Post survey responses correctly answered much of the time as 60 minutes, where the next answers selected were 30 minutes of 15 minutes. No responses of over 60 minutes were selected (Figure R3, Appendix R). The SAM tool provides reinforcement of this knowledge through routine usage at the bedside.

Prioritization. The prioritization analysis question asked nurses to place named common admission tasks in the order of completion with a follow up question requesting a repeat look at the same question for how they actually perform the tasks, prompting a second look and thoughtful reflection on their own practice. The respondents were unable to go back and change answers in previous questions. The presurvey answers were completed as expected by the project team and DNP candidate project lead. However, following post-survey analysis there was a shift in the researchers expected nursing answers.

Two informal focus groups were held to explore this question. Nurses first reported they loved the question because it made them really stop and think beyond the tasks they were doing as priority but the rationale behind it their order of completion. At the time of question development, there was a perceived correct answer by the DNP candidate researcher and clinical mentor. Prior testing of this question on selected nursing staff did not reveal this ahead of time. Following the intervention and nursing engagement in the process of the SAM prioritization tool development, the nurses had valid rationale for changing the order of a certain perceived low priority task. Obtaining a head circumference measurement was previously considered low priority yet becomes higher priority should the patient require noninvasive respiratory support to ensure accuracy of the measurement and to not interrupt critical respiratory support later in the process. Therefore, there were two correct answers depending on patient care needs' and both were counted as correct in the post-survey. The SAM prioritization was subsequently updated to prompt nursing to perform and this additional task of obtaining the head circumference measurement early in the admission process should an infant require noninvasive support. This question reinforces the importance of providing nurses an opportunity to evaluate their own practice, voice their rationale, and include them in protocol and clinical tool development. It may ultimately improve compliance if nurses are the drivers for the needed and meaningful change.

Cronbach's Alpha

Reliability testing on the survey questions was performed and analyzed with Cronbach's alpha. The result was low for the Likert scale questions of α=.119. All questions were reviewed and confirmed as correctly scaled. Cronbach's alpha testing on the prioritization questions resulted at α=.623 reinforcing reliability in this specific question. This was the first time using this survey on the NICU nursing population and a low value was expected as an aggregate. Reevaluation of the questions would be beneficial for future use of same survey (Figure R2 and Figure R4, Appendix R).

Pearson's Correlation

Several correlations were identified with Pearson's *r* for both pre and post intervention survey data collected and can be reviewed in Appendix R.

Presurvey. For staff knowledgeable about the previous checklist approach to admission process tasks showed a low positive correlation (r=.345, p=.006) for a desire for a prioritization tool, indication the ability to have a conceptual connection to a different approach. Increased feelings of being overwhelmed preintervention had a low positive correlation with years of experience (r=.319, p=.01). This may be related to that experienced NICU nursing staff are admitting and caring for the sickest patients and it may be assumed they are able to perform at a higher level with less support by charge staff organizing patient assignments on any given shift.

The desire for an admission prioritization support tool had a low negative correlation compared to years of experience as expected preintervention (r=-302, p=.017).

Postsurvey. Preintervention feelings of being overwhelmed had a low positive correlation with improved antibiotic timing knowledge following the intervention (r=.269, p=.045). Postintervention feelings of being overwhelmed had a low positive correlation with increased SAM tool use (r=.276, p=.040). Postintervention feelings of increased comfort with the admission process had a low positive correlation with desire for the SAM prioritization tool (r=.280, p=.036). Preintervention years of experience had a low positive correlation to postintervention years of experience following the educational module, likely indicated higher clinical performance matched to their more experienced counterparts (r=.270, p=.044). Post intervention feelings of being overwhelmed had a low positive correlation with post years of experience similar to preintervention (r=.362, p=.006,). Finally, postintervention used the new SAM admission support tool had a moderate positive correlation with postintervention desire for the new SAM prioritization tool (r=.441, p<.001).

Nursing Themes

Postsurvey respondents were encouraged to complete a narrative exploration to perceived barriers in the completion of the essential task for patient clinical dosing weight documentation. Seven themes were easily identified as reported barriers to achieving the initial task of entering the patient clinical dosing weight necessary to calculate and confirm appropriate drug dosing for the neonate. The barriers most named included not enough staff, admitting department delay of admission to census, no barriers, and critical illness of the neonate.

Additional themes included lack of knowledge despite the presented education, the chaotic environment, and general IT issues including inability to access the EMR. The barrier of not admitted to census for access to the chart could be overcome by teaching the bedside nursing staff how to locate the preadmitted patient prior to the admitting department adding it to the NICU census. All neonates are in a preadmitted status in this institution, are provided a medical record number prior to birth, and is searchable by maternal last name and day of birth. There is an occasional precipitous delivery that the admitting process does impact, but it is unlikely the case here with as often as it was observed in the narrative data from the staff.

The theme of a chaotic environment including poor communication amongst team members and assumption of tasks completed by others as team members mean well intermittently assisting in the admission process. Feedback from the Iowa Association of Neonatal Nurses following review of the SAM tool specifically felt this tool would also be useful for communication of completed tasks in this high acuity setting and for patient handoff if clinically necessary during the first hour of life stabilization activities.

Limitations, Recommendations, Implications for Practice

Limitations

Several limitations were recognized during this project. This project required human behavior change as a primary change factor for improvement. While statistically significant improvements were made in all steps of the aggregate process, there existed a limited time for the adoption of new behavior expectations. There is minimal to little ability to change desired elements in the CPOE system as well as specific to the EMR nursing documentation workflow. As a pediatric service line in an adult facility, many features are either not activated or knowledge is lacking on application for usual pediatric medication ordering safety measures in this organization. While some systems flaws were mitigated during this project, decade-old workaround habits proved difficult to eliminate quickly.

The novel SAM admission prioritization tool required time for use, feedback, and revisions. It is anticipated more revisions will continue to evolve to optimize admission activity prioritization and continue to standardize the unit specific revised admission process.

An important limitation included the lack of published timeline benchmark guidance to drive evidence-based change and advocacy for this vulnerable population. The only published timeline guidance for neonates occurred in the 2021 NICE guidance for the management of neonatal early onset sepsis. During this project, this guideline was updated, and the benchmark timeline was unfortunately removed. The new published guideline link is located in the systematic review tables in Appendix E. Publications referencing this timeline are now the only evidence for this previously published benchmark in recent review of the literature (Osvald and Prentice, 2014). Organizations including the AAP, CDC, publishers of golden hour concepts, and the STABLE program either imply or suggest early administration of first-dose antibiotic for EOS in neonates but continue to lack an established benchmark timeline from the decision to treat.

Recommendations

Organizational Level

Organizations that service pediatric patients that are not freestanding pediatric facilities should understand the unique elements of pediatric patient care that are unique from their adult counterparts. Proper financial and knowledge investment is necessary in the electronic medical record CPOE systems, EMR patient documentation systems, and pharmacy electronic systems to meet the patient safety needs of this population. EMR systems should be meaningful, efficient, interoperable, and serve multiple patient populations simultaneously.

Pediatric and neonatal experts should be involved in upper-level administrative decision making related to these issues surrounding time-sensitive patient care management. It is not uncommon to recruit community members through maternal/child service lines for a lifetime of commitment to an organization in the community and developing rapport with the community is essential for ongoing service line growth. The organization should embrace a culture of QI and provide incentives to support individual units to learn high quality QI through organizationally provided mentorship.

Unit Level

The neonatal intensive care unit provides a constellation of services from acute care to medical-surgical, complex cardiac, genetics, chronic care, palliative care, and hospice care within this specialty of neonatology. NICU nursing and medical leadership serve an important advocacy role for this population and should be well versed in data collection, analysis, and reporting patient outcomes to provide essential information and advocacy for resources to improve the delivery of patient care.

Patient care units should remain abreast of current benchmark recommendations and have a quality improvement system in place for ongoing surveillance for practice drift. A culture of quality and safety should be embraced to engage all neonatal stakeholder staff in voicing observations and participating in systems redesign when the need is identified. Maintaining active unit-based nurse practice councils for nursing involvement and accountability for their own practice is important. Collaborate efforts between multiple pediatric care units creates a larger voice for similar practice challenges and advocacy for needed changes.

Sustainability of process change may be improved with nurse driven identification of practice challenges and ownership of their practice to establish and maintain evidence base practice consistently at the bedside. Teaching triage and prioritization skills early in nursing careers may prevent nurses from becoming siloed in protocols or checklists that may limit critical thinking development over time.

Published Benchmark Guidance

The American Academy of Pediatrics (AAP) is viewed as experts and leaders in all pediatric patients and present clinical practice guidelines and recommendations for this population. The NICE benchmarks were not found referenced in previous or updated AAP guidelines related to neonatal sepsis, making this benchmark difficult to locate. It is recognized that such benchmarks may create conflict related to the delivery of usual standard of care and may increase a climate of litigation in the setting of poor neonatal outcomes. There should be strong consideration to improve antibiotic timing benchmark recommendations in future sepsis management guidance publications to provide foundation for application to quality improvement initiatives for this population.

Implication for Practice

Population Outcomes

There should be an awareness of population specific quality indicators and benchmarks to measure, evaluate, and improve performance on a unit level. Several indicators related to preterm neonatal outcomes have been identified but establishing time-sensitive standards related to these indicators remain vague.

Nursing Practice

For this practice problem, the nurse is recognized as the ultimate gatekeeper of critical patient information that expedites critical time-sensitive patient care activities for the neonate where the provider and pharmacy were critical communication points (Figure S1, Appendix S).

Fawcett wrote that nurses must make a conscious decision to use theories in practice and differentiates advanced practice nursing from a medical model of practice (Zaccagnini & Pechacek, 2021). The foundation of Betty Neuman's System model proved to be the perfect approach to this clinical challenge with the nurse facilitating the initiation of a new line of defense around the neonate undergoing evaluation for EOS in tertiary prevention efforts to intervene in a way that strengthens the client's internal resistance to a stressor (or multiple stressors) once occurred, attaining a new stable state (Zaccagnini & Pechacek, 2021) (Figure S2, Appendix S).

Embracing nursing as a profession over mere occupation should include placing high value on promoting autonomy in practice, emphasis on the essential contribution to quality patient care delivery, a supportive culture of continuous education, and establishing nurse driven quality improvement processes. Nurse driven QI can be highly effective, creates autonomy in practice, and promotes patient centered care and advocacy for evidenced based practice.

Advanced Practice Nursing

Doctoral prepared nurse leaders and APRN practitioners with a specialty in pediatric and neonatal patient populations provide an expert bridge between medial and nursing teams that are prepared with financial, quality improvement, research, and quality improvement leadership qualities to lead health care teams into the future. With continuous quality improvement skills in high demand, the neonatal nurse practitioner fills a need bridging bedside clinical expertise with leadership to improve patient outcomes in the NICU.

The IOM emphasizes the need for health professional programs to prepare students to be able to delivery patient care as members of an interdisciplinary teams that emphasize evidence-based practice, quality improvement, and informatics (Zaccagnini & Pechacek, 2021, p. xx). The

DNP prepared advanced practice nurse provides a unique bridge between nursing, physicians, specialty practice including physical, occupation, and speech therapy, respiratory therapy, and organizational administrative teams with a unique professional perspective, knowledge, and leadership skill set to promote interdisciplinary collaboration to lead teams to evolve health care delivery and improve health outcomes. (Weiss, Tilin, and Morgan, 2018) (Figure S3, Appendix S).

Summary

The everchanging complexities in the neonatal critical care unit requires a culture of quality and safety and routine review of benchmark data including antibiotic administration timing as a component of antibiotic stewardship. Previous neonatal early-onset sepsis management guidelines published by the NICE recommend a clear benchmark for initiation of antibiotics in newborns with suspected early-onset sepsis that has since been revised and removed since the inception of this project. Ongoing nursing education and systems improvements are required to stay abreast of current evidence-based practice guidelines to improve patient outcomes. This project established statistically improved systems components, staff workflow, and improved education and confidence in providing prompt treatment to newborns identified at risk for early-onset sepsis and requiring evaluation and treatment in a timely manner as recommended by the NICE. This project adds a foundation of nursing theory as well as practical solutions to complex systems applicable in multiple NICU settings that utilize electronic medical record CPOE order systems and ultimately increased nursing empowerment in the advocacy and care coordination for the care of the neonate in the NICU setting.

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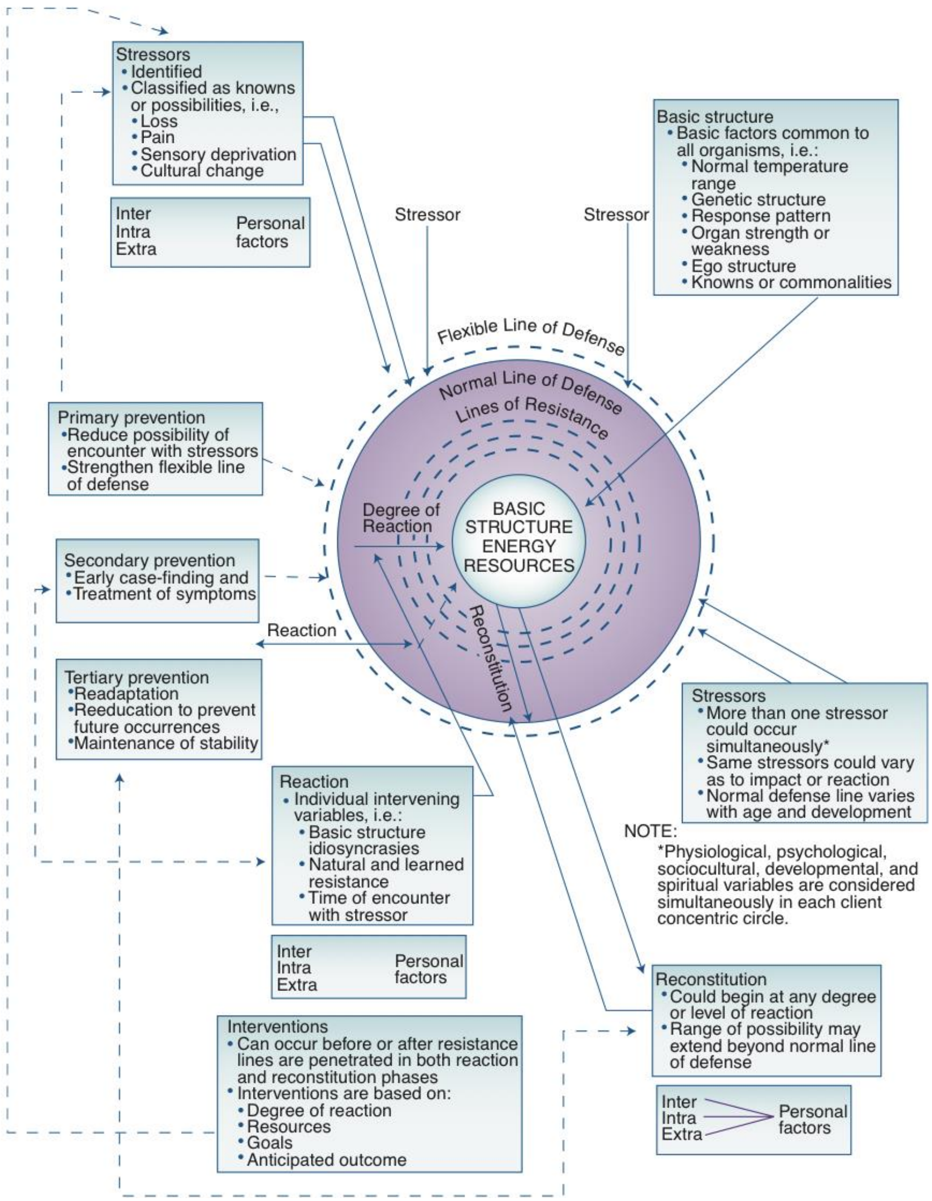
Appendices

Appendix A

Neuman's System Model

Figure A1
Betty Neuman's System Model



Note. Diagram demonstrates concept relationships in Neuman's System Model (Lowry, L.W. & Aylward, P.D., 2015, p. 168).

Appendix B

Transformational Leadership

Figure B1

Exemplary Leadership Model

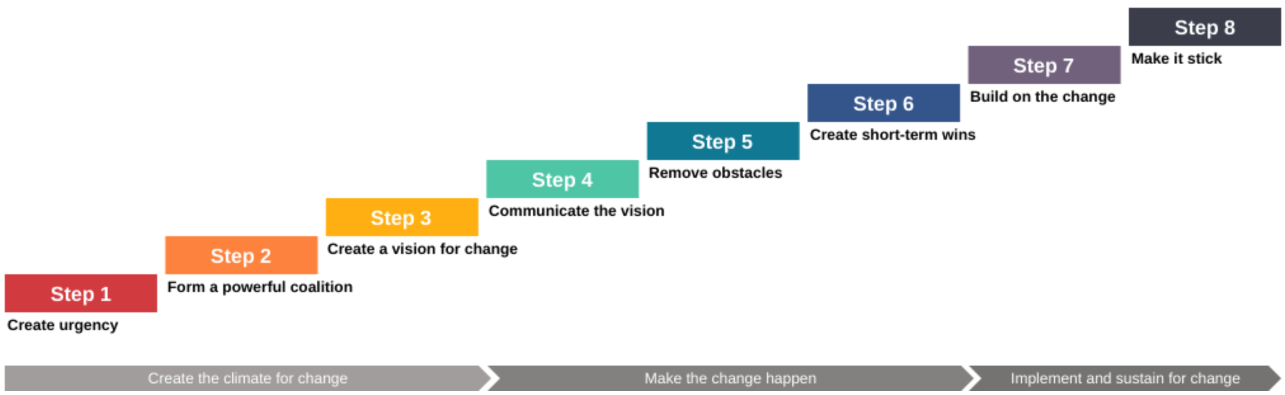
Note. Exemplary leadership behaviors to cultivate transformational leadership (Clavelle & Prado-Inzerillo, 2018, p. 39).

Appendix C

Kotter's Eight Steps for Change

Figure C1

Kotter's Eight Steps for Change



Note: Approach to implementing change with Kotter's Theory of Change (Visual Paradigm Online, n.d.).

Appendix D

Approach to the Systematic Review

Figure D1

Visual approach to the Systematic Review

SYSTEMATIC REVIEW APPROACH

Data bases: Academic Search Premier, CINAHL complete, and MEDLINE

'newborn' AND 'sepsis' 20 years	*6,607*	
**Limited years to 2017-2021*	*2577*	
*'newborn' AND '**early sepsis**'*	*1803*	
***'late preterm'** AND 'sepsis'*	*839*	*(**Seminal: Engle, Tomashek, & Wallman (2007)**)*
*'newborn' AND '**EOS sepsis calculator**'*	*103*	
Other search terms: clinical report, practice guideline, epidemiology, prematurity, neonate, sepsis and management-literature saturation		
*Intentional search for clinical practice guidelines from **ACOG (1) and AAP (5)***		
Looked to nursing organizations for any statements of standards AWHONN, NANN		
Read the cited literature form current guidelines		
CDC – defers. Active representative that participates in the committee of fetus and newborn		
Looked at similar QI projects and QI methodology in NICU (4 papers, 1 VON poster publication), **SSC, NICE benchmark*		
Golden hour concept		
Final collection included 30 applicable publications, over 12 of which were directly related to the development of the project		

Note: Visual Approach to the Systematic Review Methodology

Appendix E

Systematic Review Table

Table E1

Systematic Review Table

Article Journal	Engle, W.A., Tomashek, K.M., Wallman, C. (2007). Late-preterm infants: A population at risk. *Pediatrics, 120*(6), 1390-1401. https://doi.org/10.1542/peds.2007-2952	Stewart & Barfield. (2019). Updates on an at-risk population: Late-preterm and early-term infants. *Pediatrics, 144*(5), 1-10. https://doi.org/10.1542/peds.2019-2760	Polin, R.A. (2012). Management of neonates with suspected or proven early-onset bacterial sepsis. *Pediatrics, 129*(5), 1006-1015. https://doi.org/10.1542/peds.2012-0541
Database Keywords	Academic Search Premier, CINHAL, MEDLINE Keywords: late preterm infants AND population at risk	Academic Search Premier, CINHAL, MEDLINE Keywords: late preterm AND outcomes, late preterm infant AND update	Academic Search Premier, CINHAL, MEDLINE Keywords: neonate AND early onset sepsis AND clinical report
Research Design	No research design-expert opinion, clinical report for clinician guidance	No research design-expert opinion, clinical report for clinician guidance	No research design-expert opinion, clinical report for clinician guidance
Level of Evidence	Level 1-Clinical guidelines resulting from rigorous systematic reviews of all available literature to make recommendations	Level 1-Clinical guidelines resulting from rigorous systematic reviews of all available literature to make recommendations	Level 1-Clinical guidelines resulting from rigorous systematic reviews of all available literature to make recommendations
Article Journal	Puopolo, K.M., Benitz, W.E., & Zaoutis, T.E. (2018). Management of neonates born at $\geq$ 35 0/7 weeks' gestation with suspected or proven early onset bacterial sepsis. *Pediatrics, 142*(6), 1-10. https://doi.org/10.1542/peds.2018-2894	Puopolo, K.M., Benitz, W.E., & Zaoutis, T.E. (2018). Management of neonates born at $\leq$ 34 6/7 weeks' gestation with suspected or proven early onset bacterial sepsis. *Pediatrics, 142*(6), 1-10. https://doi.org/10.1542/peds.2018-2896	Baker, C.J., Byington, C.L., & Polin, R.A. (2011). Policy statement: recommendations for the prevention of perinatal group B Streptococcal (GBS) disease. *Pediatrics, 128*(3), 611-616. https://doi-org.dml.regis.edu/10.1542/peds.2011-1466
Database Keywords	Academic Search Premier, CINHAL, MEDLINE Keywords: neonate AND early onset sepsis AND clinical report	Academic Search Premier, CINHAL, MEDLINE Keywords: neonate AND early onset sepsis AND clinical report	CINHAL: policy statement AND prevention of GBS
Research Design	No research design-expert opinion, clinical report for clinician guidance	No research design-expert opinion, clinical report for clinician guidance, review of best evidence	No research design-expert opinion, clinical report for clinician guidance, review of best evidence
Level of Evidence	Level 1-Clinical guidelines resulting from rigorous systematic reviews of all available literature to make recommendations	Level 1-Clinical guidelines resulting from rigorous systematic reviews of all available literature to make recommendations	Level 1-Clinical guidelines resulting from rigorous systematic reviews of all available literature to make recommendations

Note: Critical literature applicable to improving antibiotic timing in EOS

Appendix E

Systematic Review Table

Table E1
Systematic Review Table cont.

Article Journal	Puopolo, K.M., Lynfield, R., & Cummings, J.J. (2019). Management of infants at risk for group B Streptococcal disease. *Pediatrics, 144*(2), 1-17. https://doi.org/10.1542/peds.2019-1881	Mukhopadhyay, S., Eichenwald, E.C., & Puopolo, K.M. (2013). Neonatal early-onset sepsis evaluations among well-appearing infants: projected impact of changes in CDC GBS guidelines. *Journal of Perinatology, 33,* 198-205. Doi: 10.1038/jp.2012.96	The American College of Obstetricians and Gynecologists. (February 2020). Prevention of Group B Streptococcal early-onset disease in Newborns. Committee Opinion, No. 797. Volume 135, number 2. https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2020/02/prevention-of-group-b-streptococcal-early-onset-disease-in-newborns Prevention of group B streptococcal early-onset disease in newborns. ACOG Committee Opinion No. 797. American College of Obstetricians and Gynecologists. Obstet Gynecol 2020;135: e51–72.
Database Keywords	CINHAL: management of infants at risk for GBS Direct link from CDC	Academic Search Premier, CINHAL, MEDLINE Keywords: early onset sepsis calculator, EOS calculator, sepsis calculator, sepsis risk AND newborn	Link from the CDC GBS website Can perform a web search for ACOG for "GBS prevention"
Research Design	Non-investigational report	Retrospective cohort	Expert opinion, clinical guideline Systematic Review
Level of Evidence	Level 1-Clinical guidelines resulting from rigorous systematic reviews of all available literature to make recommendations	Level 3 Retrospective comparative	Level 1
Article Journal	Escobar, G.J., Puopolo, K. M., Wi, S., Turk, B.J., Kuzniewicz, M.W., Walsh, E.M., Newman, T.B., Zupancic, J., Lieberman, El, Draper, D. (2014). Stratification of risk of early-onset sepsis in newborns $\geq$ 34 weeks' gestation. *Pediatrics, 133*(1), 30-36. Doi:10.1542/peds.2013-1689	Ma, C., Levin, G., Panda, S.K., Sambalingam, D., & Singh, A.P. (2020). Improving timing of antibiotics in neonates with early onset sepsis: Quality improvement project. *Journal of Neonatal-Perinatal Medicine, 13*(2), 239-246. https://doi.org.dml.regis.edu/10.3233/NPN-190293	National Institute for Health and Care Excellence. (2012, August 22). Neonatal infection (early onset): Antibiotics for prevention and treatment. https://www.nice.org.uk/guidance/cg149 *This guideline has since been updated (2022, April 20) https://www.nice.org.uk/guidance/ng195
Database Keywords	Academic Search Premier, CINHAL, MEDLINE Keywords: early onset sepsis calculator, EOS calculator, sepsis calculator, sepsis risk AND newborn	Academic Search Primer: timing of antibiotics in neonates	Google search for NICE guideline AND neonatal sepsis
Research Design	Retrospective nested case-control study	Pre-Post intervention, PDSA cycles	Clinical Practice Guideline not available published other than the NICE website
Level of Evidence	Level 3	Level 3 Retrospective/prospective cohort comparative	Level 1

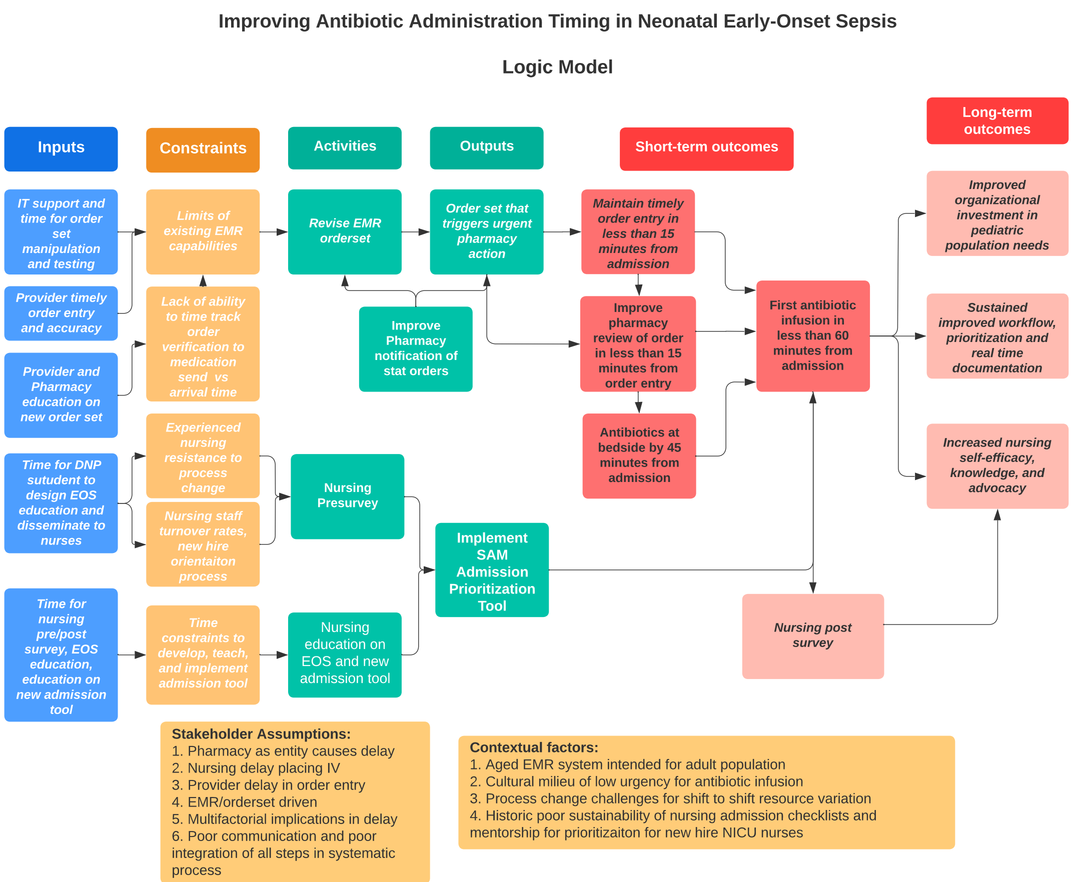
Note: Critical literature applicable to improving antibiotic timing in EOS

Appendix F

Logic Model

Figure F1

Logic Model



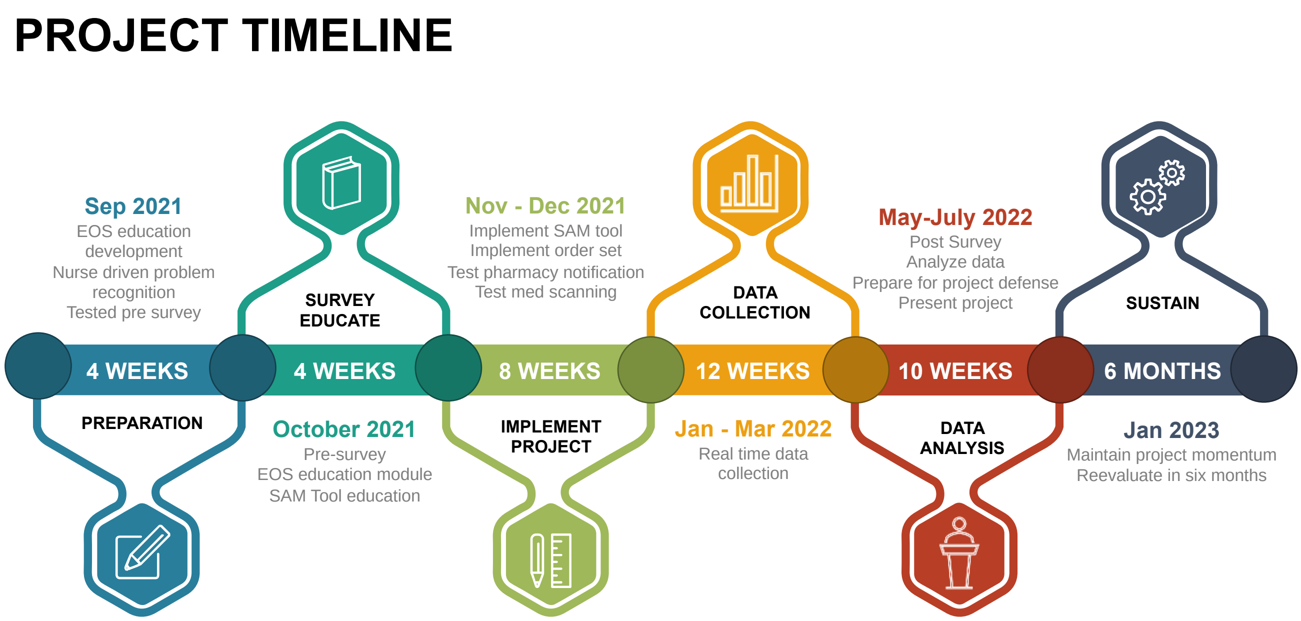
Note: Logic model for project inputs, constraints, and benchmarks to meet primary outcome for antibiotic infusion within 60 minutes from admission to NICU.

Appendix G

Project Timeframe

Figure G1

Planned project timeline



Note: Project activity planning

Appendix H

SAM Admission Prioritization Tool

Figure H1

Novel SAM Admission Prioritization Tool for Bedside Nursing

SAM Admission Prioritization Tool (Draft 2)

Stabilize **Admit time_______**

<15 minutes Post admission

Enter Clinical Dosing Wt. in EMR ☐ Rectal Temp ☐ Place on Central Monitors ☐

Vital signs ☐ BP R Arm ☐ Leg BP ☐ OFC (if on CPAP) ☐

Place OG/NG ____cm **(Prior to X-Ray)** ☐

PIV/Central Access (Goal within 15 min of admission) ☐

***Place PIV** and start **D10** if central line placement delays initiation of fluids*

*(Consider **2nd PIV** if have back up of medications/boluses)*

Blood CX ☐ CBC ☐ Blood Gas ☐ Glucose Check Initial ☐ Labs Sent ☐

Provider Physical Exam ☐ RN Physical Assessment ☐

Charting: Clinical Wt, Admission Workflow, Admission Nursing History, IV, Scan D10 ☐

Activities **30 min ________**

30 Minutes Post Admission

30 Minute Vital Signs ☐ 30 min Glucose check ☐ Length ☐ OFC ☐

Vitamin K ☐ Erythromycin Eye Ointment ☐ Hepatitis B (if appropriate) ☐

Delegate checking tube station for Antbx ☐

Check antibiotic orders for pharmacy review ☐

*(**Call Pharmacist if orders not reviewed by 30 minutes of admit**)*

Ampicillin ☐ Gentamicin ☐

DO NOT delay Ampicillin for NS bolus

(Unless ordered by provider) (Start 2nd peripheral, if needed)

Call for CXR (if ordered) ☐ Review Lab Results **AND** Notify Provider of Results ☐

Maintain **60 min________**

60+ Minutes Post Admission

1 Hour		**2 Hour**		**3 Hour**		**4 Hour**	
Glucose	☐	Glucose	☐	Glucose	☐	Glucose	☐
Vitals	☐	Vitals	☐	Vitals	☐	Vitals	☐
Chart	☐	Chart	☐	Chart	☐	Chart	☐

Provider check-in by 60 minutes post-admission

Call provider with Labs, Gas, Radiology, Notifications, Results, Updates ☐

Footprints ☐ Chart IPOC ☐ Kardex ☐ Blue Clipboard ☐ Big Chart ☐

Developmental Care ☐ Quilt ☐ Parent Communication Board ☐ Consents ☐

Update parent/parents over phone if not available at bedside

Not part of patient's permanent medical record 6/26/22

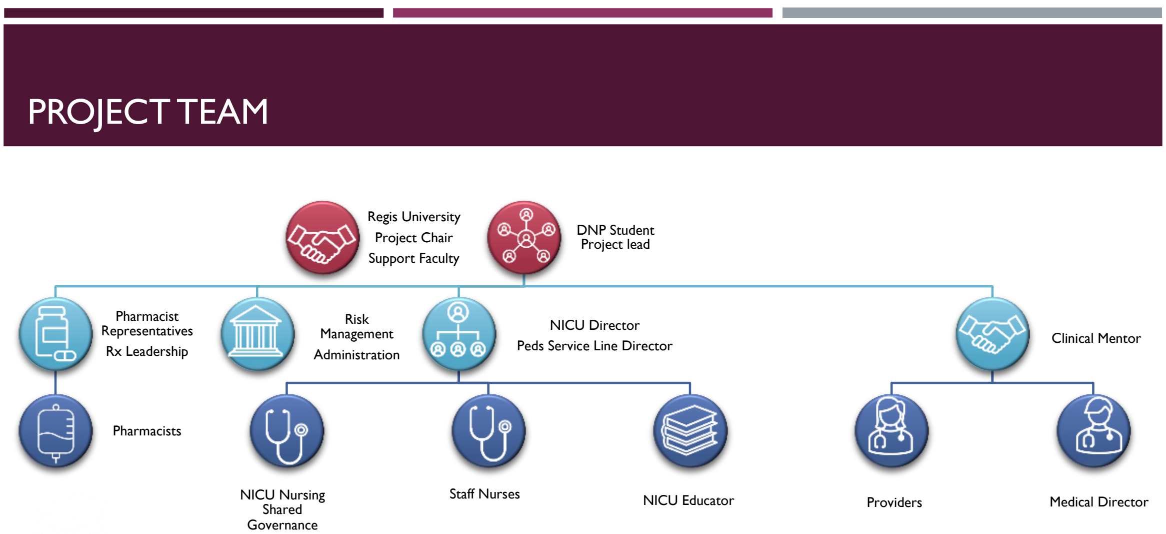
Note: Novel SAM admission tool created for the purpose of this project and specific to the nursing activities that occur in one NICU and may not apply in its entirety to all NICU environments.

Appendix I

Project Team

Figure I1

Project team organizational chart



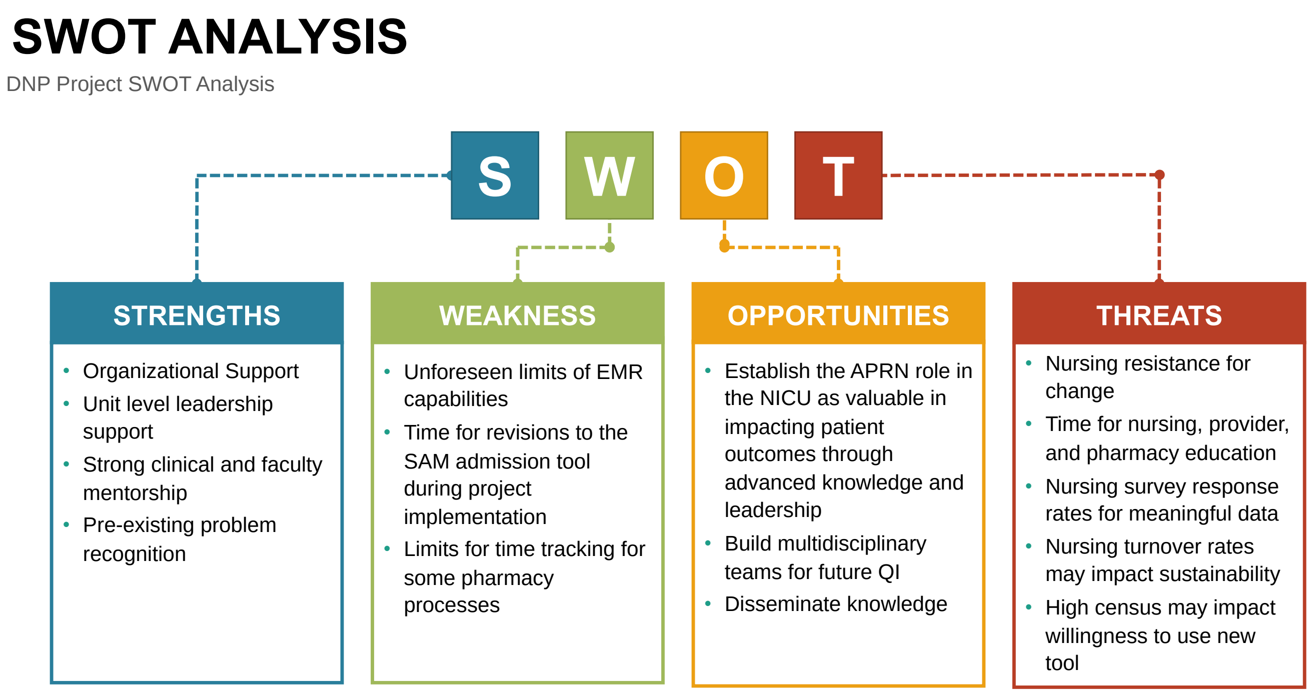
Note: Stakeholders and essential project team members

Appendix J

Project SWOT Analysis

Figure J1

Project strengths, weaknesses, opportunities, and threats



Note: SWOT analysis specific to DNP project

Appendix K

Resources and Cost-Benefit

Table K1
Project resources

Project Resources	
Organizational Culture	Congruent with culture of quality improvement, patient safety, and outcomes celebrations
NICU Unit Culture	Longstanding culture of successful quality improvement projects lead by NICU nursing leadership Pre-existing awareness and sense of urgency for project problem driven by all stakeholders Unit nursing culture to help disseminate and reinforce processes and knowledge as change agents
IRB	Strong IRB support and availability with new structured format to embrace and raise standards for QI initiatives and encouragement for publication
Pharmacy IT specialty	Pharmacy/IT combination role with access to investigate and manipulated electronic orders for improved communication
Medical director access to EMR order set for manipulation	Ability to manipulate, test, and affirm changes for implementation. Support for project and improvements
Neonatologist-QI expertise	Immediate access to clinical mentor with QI experience and expertise

Note: Project resource availability

Appendix K

Resources and Cost-Benefit

Table K2
Project Projected Costs

Cost	
DNP time	Project time and activities are donated
Nursing education time	Included in usual education time already required
Pharmacy IT and resource time	Donated as part of usual specialty project time on pharmacy QI
Pharmacy education time	Included in usual education time required
Provider education time	Included in routine monthly meeting time
Printed materials	Minimal cost for printed or laminated materials from office supplies already stocked in the unit for such activities

Table K3
Project Projected Benefit

Benefit	
Non-experimental design	All infants with EOS evaluation will receive intervention and may experience potential benefit of the improved systems process
Thorough systems analysis of multiple department workflow and communication that	May reveal additional areas that could improve from similar systems alterations
Improved knowledge and efficiency of the NICU admission	Will benefit all infants beyond the intervention time as the aim of sustainability
Dissemination of knowledge gained	Knowledge gained from this project through modes such as publications may benefit other NICU environments worldwide and are the responsibility of those conducting QI or research projects

Note: Project cost-benefit analysis

Appendix L

Context Specific Database Patient Data

Table L1

Context Specific Database Patient Data

Variable	**Variable Name**	**Measurement units**	**Allowed values**	**Definition/Description of variable**
Patient ID number	ID	Numeric	001-999	Unique patient identification
Birth date	DOB	mm/dd/yyyy	1-12/1-31/2020-2021	Date of birth
Birth Time	TOB	Numeric	0000-2359	Time of birth in military time
Gestational age	GA	Numeric	30.0-42.0	Gestational age of infant from 30 weeks to 42 weeks based on known estimated due date from obstetric dating
Type of Vascular Access	IV	Numeric	1=peripheral IV 2=central IV	Peripheral access is inclusion criteria to project
Admission to NICU Time	ADMIT	Numeric	0000-2359	Time of admission in military time
Vascular access placement time	VAT	Numeric	0-200	Minutes since admission
Order Entry Time	OET	Numeric	1-200	Minutes since admission
Pharmacy Review Time	PRT	Numeric	1-200	Minutes passed since order placed
Antibiotic Infusion Time	AIT	Numeric	1-200	Minutes passed between admission time to any antibiotic infusion time

Note: Patient data items to be collected during project

Appendix L

Context Specific Database Nursing Data

Table L2

Context Specific Database Nursing Data

Variable	Variable Name	Data Level	Measurement Units	Allowed Values	Definition of Variable
Confidence	CNFD	Ordinal	Numeric	Star rating 1-4	Star rating to rank 1-4
Overwhelmed	OVR	Ordinal	Numeric	Star rating 1-4	Star rating to rank 1-4
Knowledge of admission checklist	CHKL	Ordinal	Numeric	Star rating 1-4	Four answers. Three with same value if know tool exists. Unique low value if they do not. 1 or 3 weight
Desire for a prioritization Tool	PRTZ	Ordinal	Numeric	Star rating 1-4	Star rating to rank 1-4
Order of admission tasks	OAT	Ordinal	No Units	No values	Correct order weight, place on monitor, PIV
Order of admission tasks actual	OATA	Ordinal	No units	No values	Correct order weight, place on monitor, PIV
Knowledge of antbx timing	ATBTM	Ordinal	No units	Multiple choice, one correct answer	One correct answer – by 60 minutes of age, weighted 3 for correct answer or 1 for incorrect answer
Years of NICU nurse experience	YNE	Ordinal	Years	Scores 1-4	Multiple choice, no wrong answer, weighted by experience

Note: Nursing data items to be collected during project

Appendix M

Nursing Presurvey

Figure M1

Nursing survey pre-implementation questions

NICU Admission Process **Nursing Pre-Survey**
I feel comfortable completing a NICU admission: very uncomfortable uncomfortable comfortable very comfortable
I feel overwhelmed with the tasks required during a NICU admission: very overwhelmed overwhelmed somewhat overwhelmed not at all overwhelmed
I use the admission checklist guide during my assigned admission: I do not know what the checklist is never use sometimes use always use
Drag the admission activities in order for a NICU admission: Measurements including head circumference and length Weight Place on cardiorespiratory monitor Insert peripheral IV access Footprints
Drag the following admission activities in the order in which you *ACTUALLY* do them: Measurements including head circumference and length Weight Place on cardiorespiratory monitor Footprints Insert peripheral IV access
Antibiotics should be started before: 15 minutes after admission 30 minutes after admission 1 hour after admission 2 hours after admission
It would be helpful to have an admission tool that helped prioritize admission activities: strongly disagree disagree agree strongly agree
I have worked in the NICU for: 0-2 years 2-5 years 5-10 years more than 10 years

Note: Nursing survey pre-implementation

Appendix M

Nursing Postsurvey

Figure M2

Nursing survey post-implementation questions

NICU Admission Process **Nursing Post-Survey**
I feel comfortable completing a NICU admission: very uncomfortable   uncomfortable   comfortable   very comfortable
I feel overwhelmed with the tasks required during a NICU admission: very overwhelmed   overwhelmed   somewhat overwhelmed   not at all overwhelmed
I used the revised admission checklist guide during my assigned admission: I do not know what the checklist is   never use   sometimes use   always use
Drag the admission activities in order for a NICU admission: Measurements including head circumference and length Weight Place on cardiorespiratory monitor Insert peripheral IV access Footprints
Drag the following admission activities in the order in which you ACTUALLY do them: Measurements including head circumference and length Weight Place on cardiorespiratory monitor Footprints Insert peripheral IV access
Antibiotics should be started before: 15 minutes after admission 30 minutes after admission 1 hour after admission 2 hours after admission
It was helpful to have an admission tool that helped me prioritize admission activities: strongly disagree   disagree   agree   strongly agree
I have worked in the NICU for: 0-2 years   2-5 years   5-10 years   more than 10 years
Barriers that prevent me from entering clinical weight on admission include:

Note: Nursing survey post-implementation

Appendix N

Local IRB Approval

Figure N1

Local IRB quality improvement approval letter

MERCYONE

Institutional Review Board
Des Moines Medical Center
1111 6th Ave
Des Moines, IA 50314

T 515-247-3985
F 515-643-8987
irb@mercydesmoines.org

MercyOne.org

August 03, 2021

Donia Bass, MS, ARNP, NNP-BC
MercyOne Des Moines

RE: Improving Antibiotic Administration Timing in Neonatal Early-Onset Sepsis - Quality Improvement Determination
Study ID: DM2021-25

Dear Ms Bass:

The MercyOne Des Moines Medical Center Institutional Review Board (IRB) has received your submission for the project entitled **Improving Antibiotic Administration Timing in Neonatal Early-Onset Sepsis**. This letter certifies that the above-referenced project has been evaluated by the Vice Chair of the IRB.

This study involves a quality improvement project to Guidelines established by the National Institute for Health and Care Excellence establish a clear benchmark for antibiotic administration timing in neonates within 60 minutes from the decision to treat. Neonates requiring treatment for early-onset sepsis inconsistently receive antibiotics within one hour from decision to treat as recommended by the NICE (NICE, 2012). This quality improvement project will aim to improve the time-sensitive management of neonates requiring evaluation for suspected early-onset sepsis by improving antibiotic administration infusion timing within 60 minutes of admission to the NICU with a standardized neonatal admission process. We will be evaluating systems process and provide usual continuing education to staff to improve our time-sensitive management of neonatal early onset sepsis in the NICU.. After review of the submitted project, the Vice Chair has determined that this activity is not human subject research per DHSS Regulations.

If your project is revised, the IRB will need to reevaluate your project's regulatory status.

This IRB operates in accordance with all local and federal applicable laws, regulations, and guidelines for research. Compliance is maintained with the FDA Code of Federal Regulations, Office for Human Rights Protections (OHRP), Good Clinical Practice (GCP) guidelines, and International Conference of Harmonization (ICH). All documentation is maintained in the study file per FDA/DHHS Regulations and IRB Guidelines.

Should you have any questions, please feel free to contact the IRB office at (515) 247-3985.

Sincerely,

Rosemary Mullin, RN, MS

Rosemary Mullin, RN, MS
Vice Chair, MercyOne Des Moines Medical Center IRB

Note: Local IRB letter of QI approval

Appendix N

Regis University IRB Approval

Figure N2

Regis IRB quality improvement approval letter

REGIS UNIVERSITY

REGIS.EDU

Institutional Review Board

DATE:	August 26, 2021
TO:	Donia Bass, MS
FROM:	Regis University Human Subjects IRB
PROJECT TITLE:	[1787582-1] Improving Antibiotic Administration Timing in Neonatal Early-Onset Sepsis
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF NOT RESEARCH
DECISION DATE:	August 26, 2021

Thank you for your submission of New Project materials for this project. The Regis University Human Subjects IRB has determined this project does not meet the definition of human subject research under the purview of the IRB according to federal regulations.

The project may proceed as written.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact the Institutional Review Board at irb@regis.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Regis University Human Subjects IRB's records.

- 1 -

Generated on IRBNet

Note: Regis IRB letter of QI approval

Appendix N

Local Unit Letter of Support

Figure N3
Local unit letter of support

MERCYONE
Children's Hospital

Variety Neonatal Intensive Care Unit
1111 6th Ave.
Des Moines, IA 50314

T 515-358-4000

MercyOne.org

Letter of Agreement

7/21/21

To Regis University Institutional Review Board (IRB):

I am familiar with Donia Bass's (NNP-BC, MS, ARNP, CLC), quality improvement project entitled *"Improving Antibiotic Administration Timing in Neonatal Early-Onset Sepsis"*. As the project will employ a Population-Intervention-Comparative-Outcome format, Mednax's/MercyOne's involvement will include access to patient data through each agency's EMR and cooperation from both the nursing and pharmacy sections. Both of the specific area's participation is included in either their required continuing education activities or required project days. Therefore, neither area will have a significant cost for participation.

I understand that this quality improvement project will be carried out following sound ethical principles and provides confidentiality of project data, as described in the proposal.

Therefore, as a representative of Mednax's/MercyOne's, I agree that Donia Bass's (NNP-BC, MS, ARNP, CLC) quality improvement project may be conducted at our agency/institution.

Sincerely,

Cary Murphy MD
Medical Director MercyOne NICU
Medical Director Neonatal Transport
Mednax Group of Iowa
Email: cary_murphy@mednax.com
Work phone: 515-358-4000

Note: Letter of support

Appendix N

CITI training

Figure N4

CITI human subjects' protections training

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)
COMPLETION REPORT - PART 1 OF 2
COURSEWORK REQUIREMENTS*

* NOTE: Scores on this Requirements Report reflect quiz completions at the time all requirements for the course were met. See list below for details. See separate Transcript Report for more recent quiz scores, including those on optional (supplemental) course elements.

- **Name:** Donia Bass (ID: 9590244)
- **Institution Affiliation:** Regis University (ID: 745)
- **Institution Email:** dbass@regis.edu
- **Institution Unit:** Nursing

- **Curriculum Group:** Human Research
- **Course Learner Group:** Biomedical Research Investigators
- **Stage:** Stage 1 - Basic Course

- **Record ID:** 40280640
- **Completion Date:** 08-Jan-2021
- **Expiration Date:** 08-Jan-2024
- **Minimum Passing:** 80
- **Reported Score*:** 98

REQUIRED AND ELECTIVE MODULES ONLY	DATE COMPLETED	SCORE
Recognizing and Reporting Unanticipated Problems Involving Risks to Subjects or Others in Biomedical Research (ID: 14777)	15-Dec-2020	5/5 (100%)
Populations in Research Requiring Additional Considerations and/or Protections (ID: 16680)	15-Dec-2020	5/5 (100%)
Conflicts of Interest in Human Subjects Research (ID: 17464)	08-Jan-2021	4/5 (80%)
History and Ethics of Human Subjects Research (ID: 498)	15-Dec-2020	5/5 (100%)
Basic Institutional Review Board (IRB) Regulations and Review Process (ID: 2)	15-Dec-2020	5/5 (100%)
Informed Consent (ID: 3)	15-Dec-2020	5/5 (100%)
Records-Based Research (ID: 5)	15-Dec-2020	3/3 (100%)
Research and HIPAA Privacy Protections (ID: 14)	15-Dec-2020	5/5 (100%)
Consent and Biobanks and Associated Databases (ID: 17254)	15-Dec-2020	5/5 (100%)
Belmont Report and Its Principles (ID: 1127)	04-Dec-2020	3/3 (100%)
FDA-Regulated Research (ID: 12)	15-Dec-2020	5/5 (100%)

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid Independent Learner.

Verify at: www.citiprogram.org/verify/?k0e0b5ce6-eea4-4aa2-9632-70d582833240-40280640

Collaborative Institutional Training Initiative (CITI Program)
Email: support@citiprogram.org
Phone: 888-529-5929
Web: https://www.citiprogram.org

Note: CITI training modules

Appendix N

CITI training cont.

Figure N5

CITI human subjects' protections training

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)
COMPLETION REPORT - PART 2 OF 2
COURSEWORK TRANSCRIPT**

** NOTE: Scores on this Transcript Report reflect the most current quiz completions, including quizzes on optional (supplemental) elements of the course. See list below for details. See separate Requirements Report for the reported scores at the time all requirements for the course were met.

- Name: Donia Bass (ID: 9590244)
- Institution Affiliation: Regis University (ID: 745)
- Institution Email: dbass@regis.edu
- Institution Unit: Nursing

- Curriculum Group: Human Research
- Course Learner Group: Biomedical Research Investigators
- Stage: Stage 1 - Basic Course

- Record ID: 40280640
- Report Date: 18-Jan-2021
- Current Score**: 99

REQUIRED, ELECTIVE, AND SUPPLEMENTAL MODULES	MOST RECENT	SCORE
Basic Institutional Review Board (IRB) Regulations and Review Process (ID: 2)	15-Dec-2020	5/5 (100%)
Informed Consent (ID: 3)	15-Dec-2020	5/5 (100%)
Social and Behavioral Research (SBR) for Biomedical Researchers (ID: 4)	15-Dec-2020	4/4 (100%)
Consent and Biobanks and Associated Databases (ID: 17254)	15-Dec-2020	5/5 (100%)
Belmont Report and Its Principles (ID: 1127)	04-Dec-2020	3/3 (100%)
Consent and Cultural Competence (ID: 17263)	10-Jan-2021	4/5 (80%)
Records-Based Research (ID: 5)	15-Dec-2020	3/3 (100%)
Research Involving Children (ID: 9)	10-Jan-2021	3/3 (100%)
Research Involving Pregnant Women, Fetuses, and Neonates (ID: 10)	10-Jan-2021	3/3 (100%)
FDA-Regulated Research (ID: 12)	15-Dec-2020	5/5 (100%)
Research and HIPAA Privacy Protections (ID: 14)	15-Dec-2020	5/5 (100%)
History and Ethics of Human Subjects Research (ID: 498)	15-Dec-2020	5/5 (100%)
Recognizing and Reporting Unanticipated Problems Involving Risks to Subjects or Others in Biomedical Research (ID: 14777)	15-Dec-2020	5/5 (100%)
Populations in Research Requiring Additional Considerations and/or Protections (ID: 16680)	15-Dec-2020	5/5 (100%)
Data and Safety Monitoring in Human Subjects Research (ID: 17433)	15-Dec-2020	5/5 (100%)
Conflicts of Interest in Human Subjects Research (ID: 17464)	08-Jan-2021	5/5 (100%)

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid Independent Learner.

Verify at: www.citiprogram.org/verify/?k0e0b5ce6-eea4-4aa2-9632-70d582833240-40280640

Collaborative Institutional Training Initiative (CITI Program)
Email: support@citiprogram.org
Phone: 888-529-5929
Web: https://www.citiprogram.org

Note: CITI training modules

Appendix O

Power Analysis

Table O1

Power analysis tables for patient census needed for independent groups

Power Analysis Table

Test for Mean Difference[a]	N1	N2	Actual Power[b]	Test Assumptions Power	Effect Size[c]	Sig.
1	64	64	.801	.800	.5	.05
2	73	73	.851	.850	.5	.05
3	86	86	.903	.900	.5	.05
4	105	105	.950	.950	.5	.05

a. Two-sided test.
b. Based on noncentral t-distribution.
c. Group variances are assumed to be equal.

Note: Power analysis in SPSS (2022).

Table O2

Power analysis tables for nursing survey completion needed for dependent groups

Power Analysis Table

Test for Mean Difference[a]	N[b]	Actual Power[c]	Test Assumptions Power	Effect Size	Sig.
1	34	.808	.800	.5	.05
2	38	.851	.850	.5	.05
3	44	.900	.900	.5	.05
4	54	.950	.950	.5	.05

a. Two-sided test.
b. Number of pairs.
c. Based on noncentral t-distribution.

Note: Power analysis confirmed in SPSS (2022).

Appendix P

Patient Demographics

Table P1

Patient demographic data pre/post intervention

PROJECT FINDINGS

PATIENT DEMOGRAPHICS

Pre-Intervention	Gestational age	*n*
Preterm	< 33 6/7 weeks	44
Late Preterm	34 0/7 -36 6/7 weeks	56*
Early Term	37 0/7-38 6/7 weeks	26
Term	>39 0/7 weeks	34
	Birthweight	*n*
ELBW	<1000 grams	6
VLBW	<1500 grams	17
LBW	1500-2500 grams	56
LGA/Macrosomia	> 4000 grams	14
Outborn Transfers		15

Post-Intervention	Gestational age	*n*
Preterm	< 33 6/7 weeks	51
Late Preterm	34 0/7 -36 6/7 weeks	51*
Early Term	37 0/7-38 6/7 weeks	23
Term	>39 0/7 weeks	21
	Birthweight	*n*
ELBW	<1000 grams	11
VLBW	<1500 grams	8
LBW	1500-2500 grams	70
LGA/Macrosomia	> 4000 grams	11
Outborn Transfers		11

Pre-Intervention	Total admissions	Admits with antibiotics *n*	Included *n*	% admits with antibiotics
Jun-22	60	43	30	71.60%
Jul-21	57	41	28	71.90%
Aug-21	43	36	21	81.8%%
	160			

Post-Intervention	Total admissions	Admits with antibiotics n	Included n	% admits with antibiotics
22-Jan	55	38	28	70.30%
22-Feb	44	33	20	75%
22-Mar	47	31	21	65.90%
	146			

Note: Unit patient demographics pre/post intervention.

Appendix P

Clinical Dosing Weight

Figure P1

Clinical dosing weight documentation pre/post intervention

PATIENT OUTCOMES

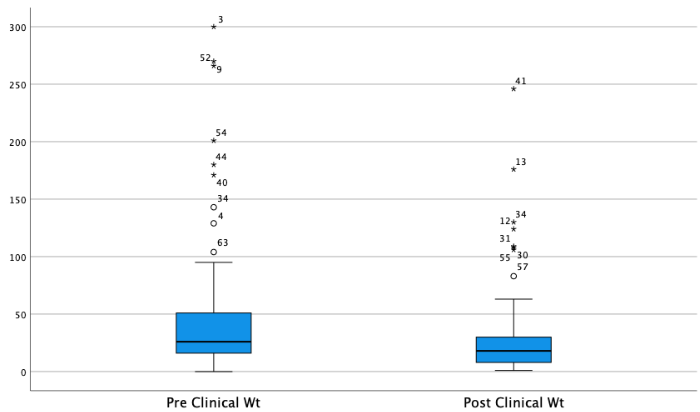
CLINICAL DOSING WEIGHT

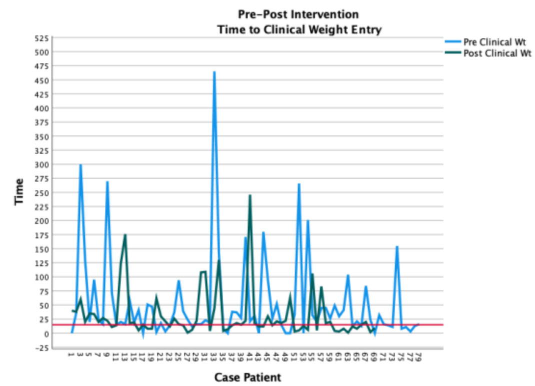
Paired Samples Test

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Pre Clinical Wt - Post Clinical Wt	24.986	93.291	11.231	2.575	47.396	2.225	68	.015	.029

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Clinical Wt	56.52	69	82.222	9.898
	Post Clinical Wt	31.54	69	43.450	5.231





Note: Data analysis in SPSS (2022). Box plot with significant improvement of distribution of documented time (p=0.029). Run chart with goal time depicted by red line for 15 minutes from admission.

Appendix P

Provider Order Entry

Figure P2

Provider order entry timing pre/post intervention

PATIENT OUTCOMES

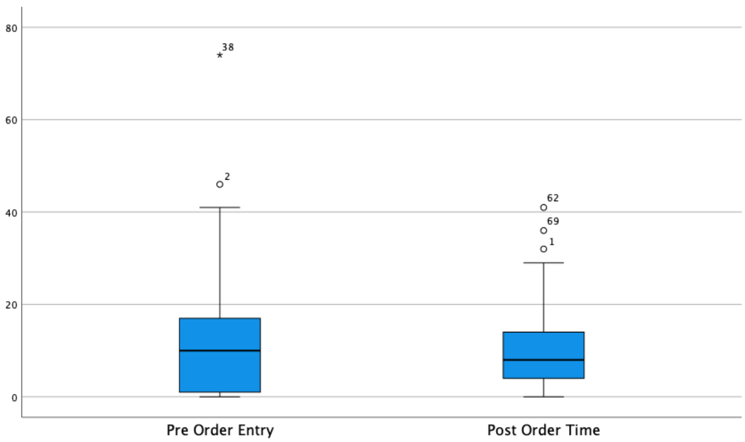
PROVIDER ORDER ENTRY

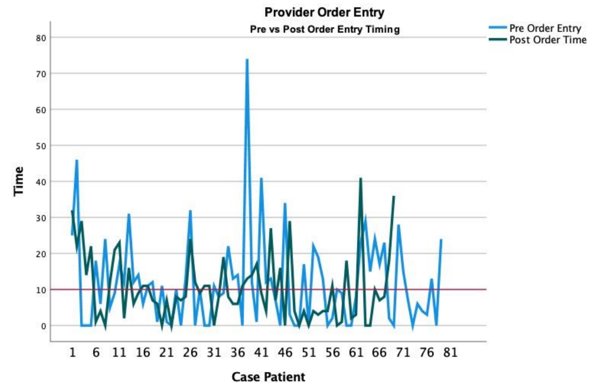
Paired Samples Test

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Pre Order Entry - Post Order Time	1.681	15.868	1.910	-2.131	5.493	.880	68	.191	.382

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Order Entry	12.07	69	13.154	1.584
	Post Order Time	10.39	69	9.434	1.136





Note: Data analysis in SPSS (2022). Benchmark data. Expected outcome no significant change (*p*=0.382). While not statistically significant, order entry timing did however improve as a distribution despite addition of new providers.

Appendix P

Pharmacy Review of Orders

Figure P3

Pharmacy review of order timing pre/post intervention

PATIENT OUTCOMES

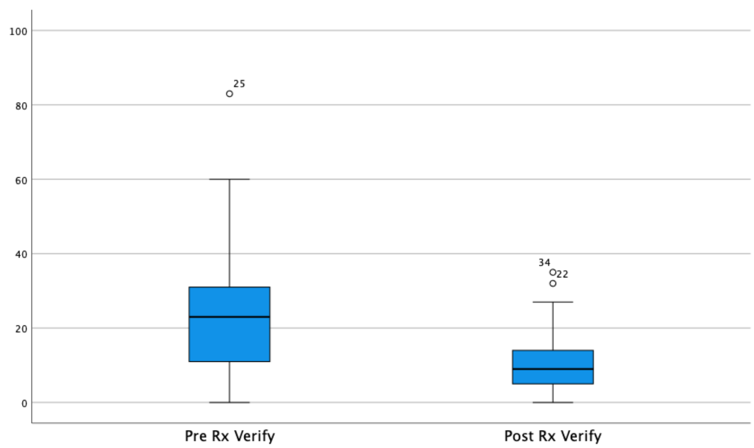
RX REVIEW OF ORDERS

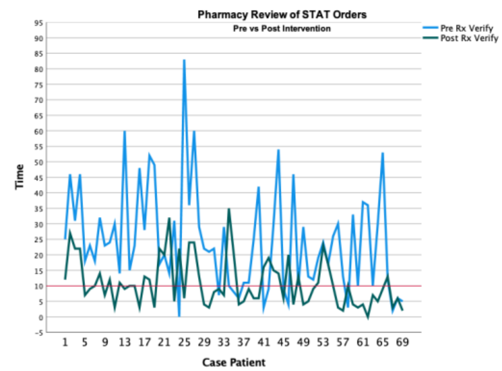
Paired Samples Test

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Pre Rx Verify - Post Rx Verify	13.580	18.751	2.257	9.075	18.084	6.016	68	<.001	<.001

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Rx Verify	24.55	69	16.718	2.013
	Post Rx Verify	10.97	69	7.723	.930





Note: Data analysis in SPSS (2022). Box plot with statistically significant improvement of distribution of documented time (p<0.001). Run chart with goal time depicted by red line for 10 minutes from admission.

Appendix P

Nursing Peripheral Access

Figure P4

Nursing peripheral access placement timing pre/post intervention

PATIENT OUTCOMES

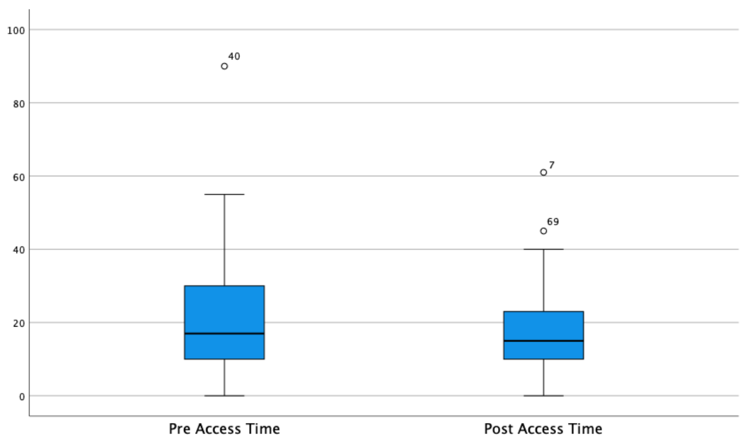
RN PERIPHERAL ACCESS PLACEMENT

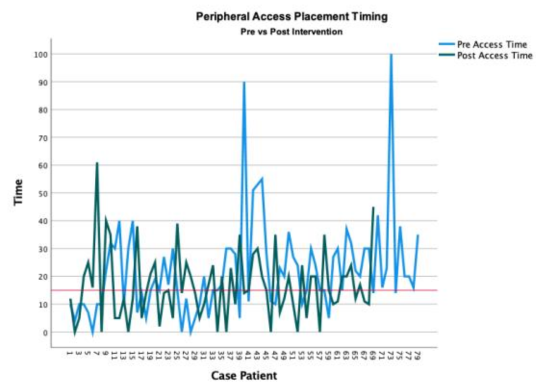
Paired Samples Test

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Pre Access Time – Post Access Time	4.101	19.891	2.395	-.677	8.880	1.713	68	.046	.091

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Access Time	20.74	69	15.027	1.809
	Post Access Time	16.64	69	12.350	1.487





Note: Data analysis in SPSS (2022). Benchmark data. Expected outcome no statistically significant change (p=0.091). Despite nursing attrition and new graduate registered nurses, while not statistically significant, times did overall improve.

Appendix P

Antibiotic Infusion Timing

Figure P5

First dose antibiotic infusion timing pre/post intervention

PATIENT OUTCOMES

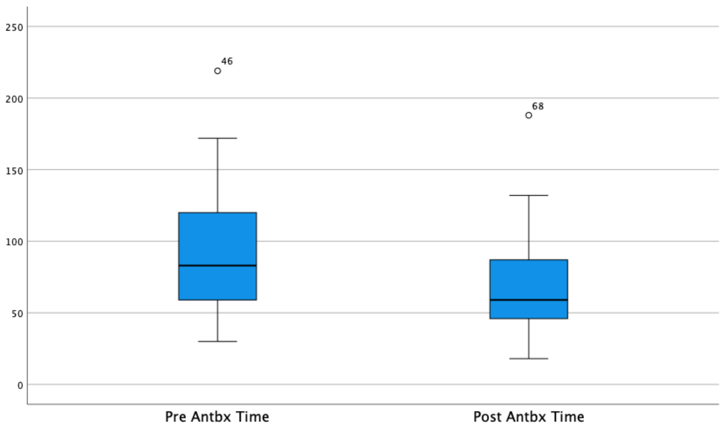
ANTIBIOTIC TIMING

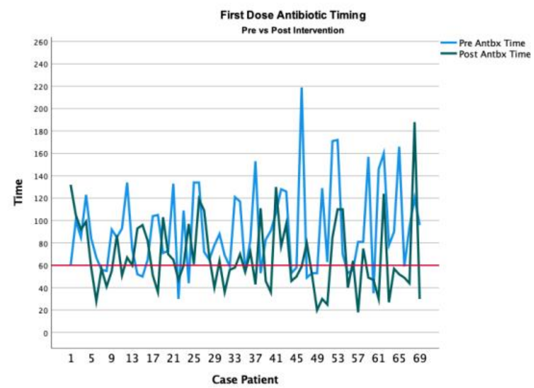
Paired Samples Test

		Paired Differences							Significance	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Pre Antbx Time - Post Antbx Time	24.362	46.807	5.635	13.118	35.607	4.323	68	<.001	<.001

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Antbx Time	91.61	69	38.920	4.685
	Post Antbx Time	67.25	69	31.978	3.850





Note: Data analysis in SPSS (2022). Box plot with statistically significant improvement of distribution of documented time (p<0.001). Run chart with goal time depicted by red line for 60 minutes from admission.

Appendix P

Patient Data Correlations

Table P2

Pearson's correlation coefficient

CORRELATIONS

PATIENT DATA

Post Intervention Correlation	*p* value	Pearson's	Pos/Neg	Level
Post Rx Verify Post Antbx Timing	.011	.306	Positive	Low
Post Order Entry Post Antbx Timing	<.001	.401	Positive	Moderate

Note: Data analysis in SPSS (2022). Two correlations identified with clinical application.

Appendix Q

Antibiotic Infusion Frequency Table

Table Q1

Antibiotic infusion time frequencies

Pre Antbx Time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30	1	.3	1.3	1.3
	35	1	.3	1.3	2.5
	44	1	.3	1.3	3.8
	47	1	.3	1.3	5.1
	49	2	.5	2.5	7.6
	50	1	.3	1.3	8.9
	52	1	.3	1.3	10.1
	53	5	1.3	6.3	16.5
	55	2	.5	2.5	19.0
	56	2	.5	2.5	21.5
	58	1	.3	1.3	22.8
	59	3	.8	3.8	26.6
	60	1	.3	1.3	27.8
	63	1	.3	1.3	29.1
	65	3	.8	3.8	32.9
	67	1	.3	1.3	34.2
	69	1	.3	1.3	35.4
	70	1	.3	1.3	36.7
	71	1	.3	1.3	38.0
	72	1	.3	1.3	39.2
	73	1	.3	1.3	40.5
	74	1	.3	1.3	41.8
	77	1	.3	1.3	43.0
	78	2	.5	2.5	45.6
	81	2	.5	2.5	48.1
	82	1	.3	1.3	49.4
	83	1	.3	1.3	50.6
	84	1	.3	1.3	51.9
	85	2	.5	2.5	54.4
	88	1	.3	1.3	55.7
	90	2	.5	2.5	58.2
	91	1	.3	1.3	59.5
	92	1	.3	1.3	60.8
	93	1	.3	1.3	62.0
	94	1	.3	1.3	63.3
	96	1	.3	1.3	64.6
	100	1	.3	1.3	65.8
	103	1	.3	1.3	67.1
	104	1	.3	1.3	68.4
	105	1	.3	1.3	69.6
	107	1	.3	1.3	70.9
	109	1	.3	1.3	72.2
	117	1	.3	1.3	73.4
	120	1	.3	1.3	74.7
	121	1	.3	1.3	75.9
	122	1	.3	1.3	77.2
	123	1	.3	1.3	78.5
	126	1	.3	1.3	79.7
	128	1	.3	1.3	81.0
	129	1	.3	1.3	82.3
	133	1	.3	1.3	83.5
	134	3	.8	3.8	87.3
	146	1	.3	1.3	88.6
	153	1	.3	1.3	89.9
	155	1	.3	1.3	91.1
	156	1	.3	1.3	92.4
	157	1	.3	1.3	93.7
	160	1	.3	1.3	94.9
	166	1	.3	1.3	96.2
	171	1	.3	1.3	97.5
	172	1	.3	1.3	98.7
	219	1	.3	1.3	100.0
	Total	79	20.0	100.0	
Missing	System	316	80.0		
Total		395	100.0		

Post Antbx Time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18	1	.3	1.4	1.4
	20	1	.3	1.4	2.9
	25	1	.3	1.4	4.3
	27	1	.3	1.4	5.8
	28	1	.3	1.4	7.2
	30	3	.8	4.3	11.6
	36	3	.8	4.3	15.9
	40	2	.5	2.9	18.8
	41	1	.3	1.4	20.3
	43	1	.3	1.4	21.7
	44	1	.3	1.4	23.2
	46	2	.5	2.9	26.1
	47	2	.5	2.9	29.0
	49	2	.5	2.9	31.9
	50	1	.3	1.4	33.3
	51	2	.5	2.9	36.2
	52	2	.5	2.9	39.1
	54	1	.3	1.4	40.6
	55	1	.3	1.4	42.0
	56	1	.3	1.4	43.5
	57	2	.5	2.9	46.4
	58	2	.5	2.9	49.3
	59	1	.3	1.4	50.7
	60	2	.5	2.9	53.6
	61	1	.3	1.4	55.1
	64	2	.5	2.9	58.0
	65	1	.3	1.4	59.4
	67	1	.3	1.4	60.9
	68	1	.3	1.4	62.3
	70	2	.5	2.9	65.2
	72	1	.3	1.4	66.7
	75	1	.3	1.4	68.1
	77	1	.3	1.4	69.6
	80	1	.3	1.4	71.0
	82	1	.3	1.4	72.5
	85	1	.3	1.4	73.9
	87	1	.3	1.4	75.4
	92	1	.3	1.4	76.8
	93	1	.3	1.4	78.3
	96	1	.3	1.4	79.7
	97	2	.5	2.9	82.6
	99	1	.3	1.4	84.1
	103	1	.3	1.4	85.5
	105	1	.3	1.4	87.0
	109	1	.3	1.4	88.4
	110	2	.5	2.9	91.3
	111	1	.3	1.4	92.8
	119	1	.3	1.4	94.2
	124	1	.3	1.4	95.7
	130	1	.3	1.4	97.1
	132	1	.3	1.4	98.6
	188	1	.3	1.4	100.0
	Total	69	17.5	100.0	
Missing	System	326	82.5		
Total		395	100.0		

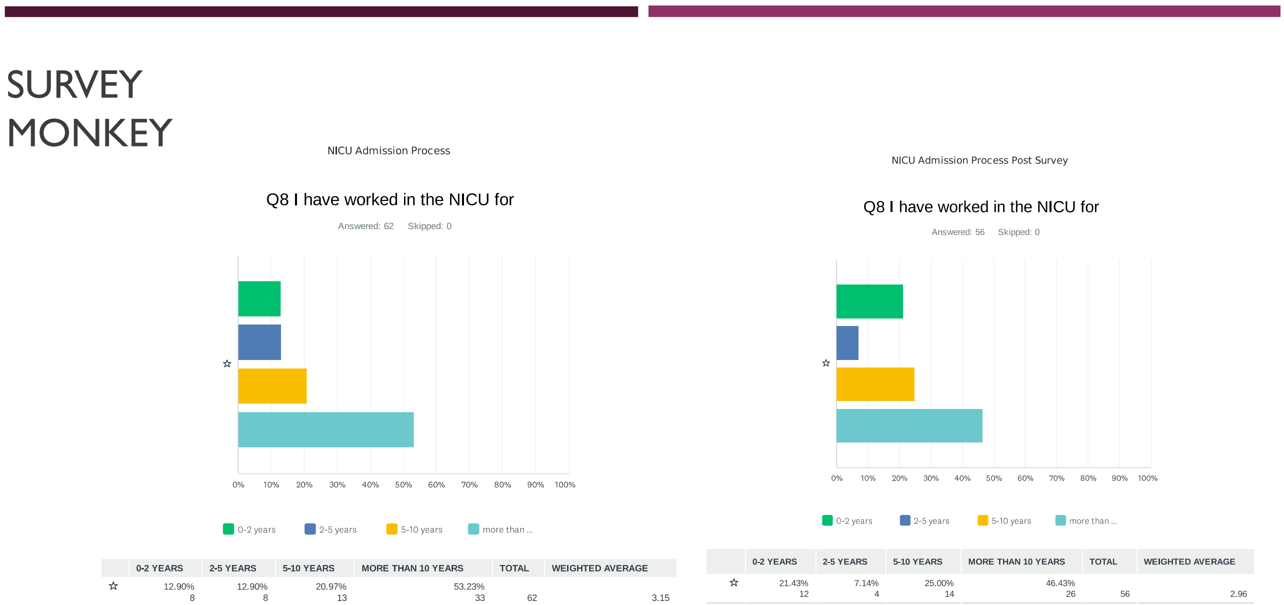
Note: Data analysis in SPSS (2022). Frequencies for time to infusion.

Appendix R

Nursing Survey Years of Experience

Figure R1

Nursing survey response based on years of experience.



	0-2 YEARS	2-5 YEARS	5-10 YEARS	MORE THAN 10 YEARS	TOTAL	WEIGHTED AVERAGE
☆	12.90% 8	12.90% 8	20.97% 13	53.23% 33	62	3.15

	0-2 YEARS	2-5 YEARS	5-10 YEARS	MORE THAN 10 YEARS	TOTAL	WEIGHTED AVERAGE
☆	21.43% 12	7.14% 4	25.00% 14	46.43% 26	56	2.96

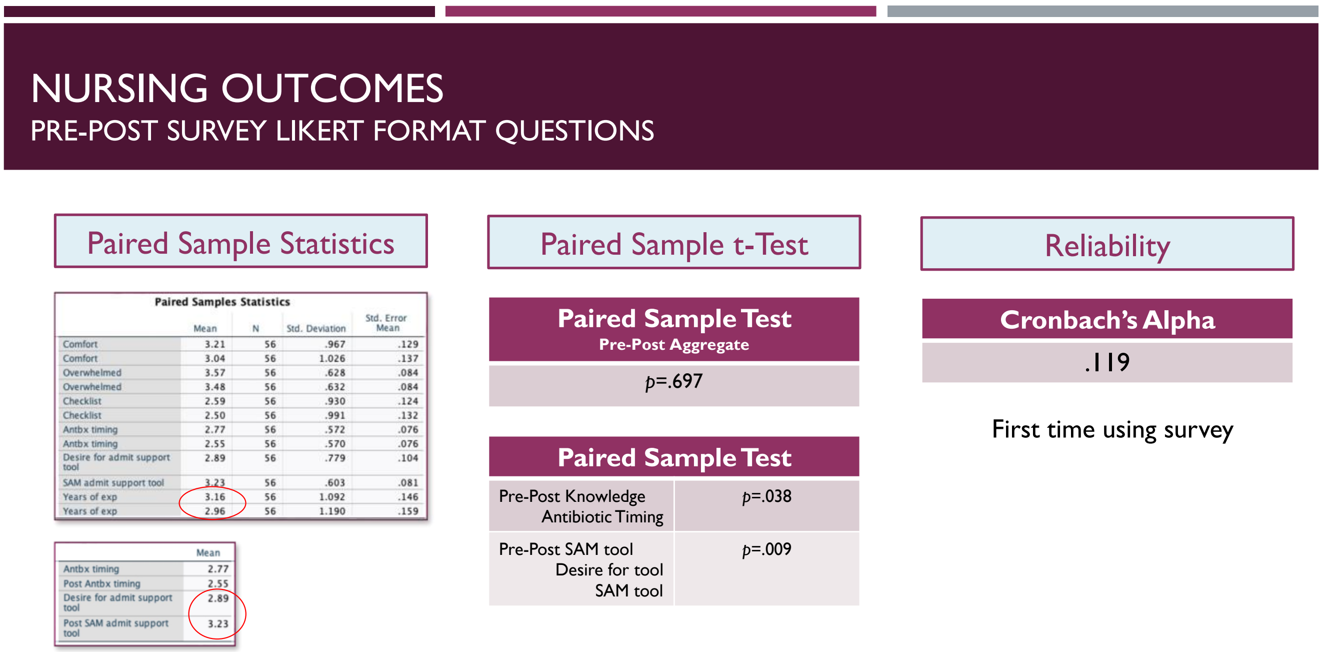
Note: Nursing survey years of experience provided from Survey Monkey (2022).

Appendix R

Nursing Survey Results

Figure R2

Nursing survey questions



Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
Comfort	3.21	56	.967	.129
Comfort	3.04	56	1.026	.137
Overwhelmed	3.57	56	.628	.084
Overwhelmed	3.48	56	.632	.084
Checklist	2.59	56	.930	.124
Checklist	2.50	56	.991	.132
Antbx timing	2.77	56	.572	.076
Antbx timing	2.55	56	.570	.076
Desire for admit support tool	2.89	56	.779	.104
SAM admit support tool	3.23	56	.603	.081
Years of exp	3.16	56	1.092	.146
Years of exp	2.96	56	1.190	.159

	Mean
Antbx timing	2.77
Post Antbx timing	2.55
Desire for admit support tool	2.89
Post SAM admit support tool	3.23

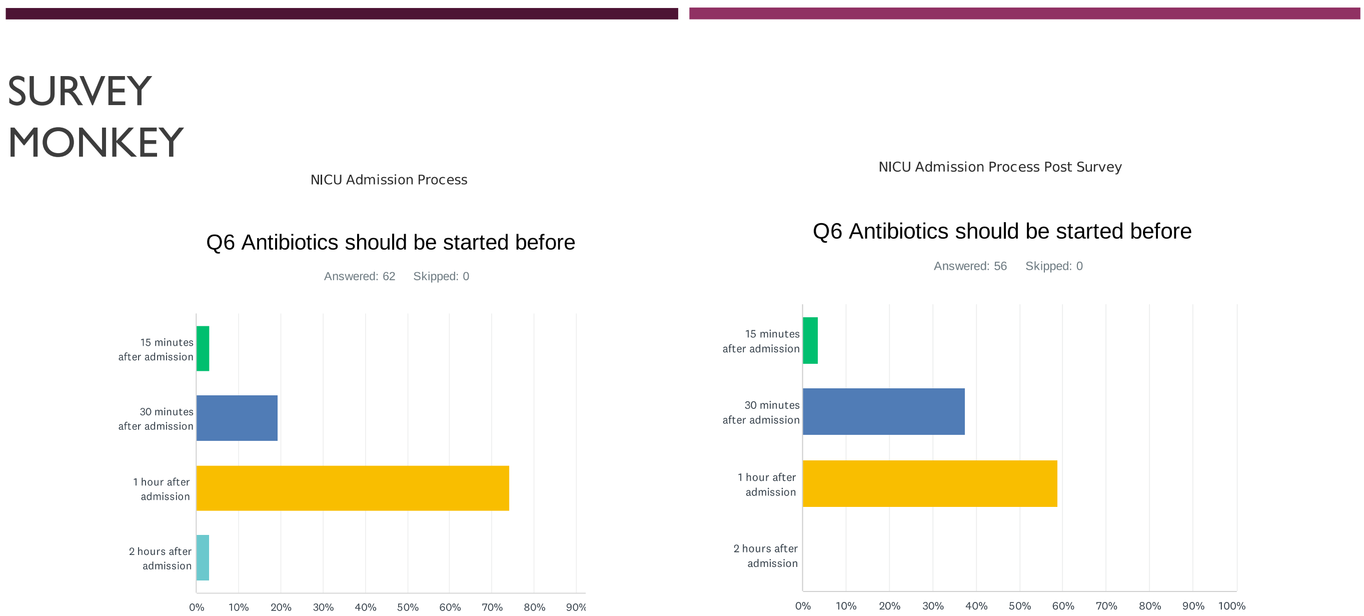
Note: Nursing survey outcomes. Data analysis in SPSS (2022).

Appendix R

Nursing Survey Knowledge

Figure R3

Nursing knowledge question



Note: Nursing survey outcomes provided from Survey Monkey (2022).

Appendix R

Nursing Survey Prioritization

Figure R4

Nursing prioritization question

NURSING OUTCOMES

PRE-POST SURVEY PRIORITY QUESTIONS

Paired Sample Statistics

		Mean
Pair 1	Priority order Exp	1.39
	Post Priority order Exp	1.79
Pair 2	Priority order actual	1.27
	Post Priority order actual	1.64
Pair 3	PreAgg	1.36
	PostAgg	1.71

Paired Sample t-Test

Paired Sample Test	
Pre-Post Priority order Expected	$p<.001$
Pre-Post Priority Actual	$p<.001$
Pre-Post Priority Aggregate	$p<.001$

Reliability

Cronbach's Alpha
.623

Note: Nursing survey outcomes. Data analysis in SPSS (2022).

Appendix R

Nursing Data Correlations

Table R1
Pearson's correlation coefficient

CORRELATIONS

Pre-Intervention Nursing Survey	p value	Pearson's	Pos/Neg	Level
Checklist use vs Desire for Priority Support tool	.006	.345	Positive	Low
Overwhelmed vs Years of experience	.011	.319	Positive	Low
Desire for a support tool vs Years of experience	.017	-.302	Negative	Low

Note: Nursing survey correlations. Data analysis with SPSS (2022).

Appendix R

Nursing Data Correlations cont.

Table R2
Pearson's correlation coefficient cont.

CORRELATIONS

Post-Intervention Nursing Survey	*p* value	Pearson's	Pos/Neg	Level
Pre Overwhelmed Post antibiotic knowledge	.045	.269	Positive	low
Post overwhelmed Post SAM tool use	.040	.276	Positive	low
Post comfort Post desire for SAM support tool	.036	.280	Positive	low
Pre years of experience Post years of experience	.044	.270	Positive	low
Post Overwhelmed Post years of experience	.006	.362	Positive	low
Post used new SAM Post desire for SAM tool	**<.001**	**.441**	**Positive**	**moderate**

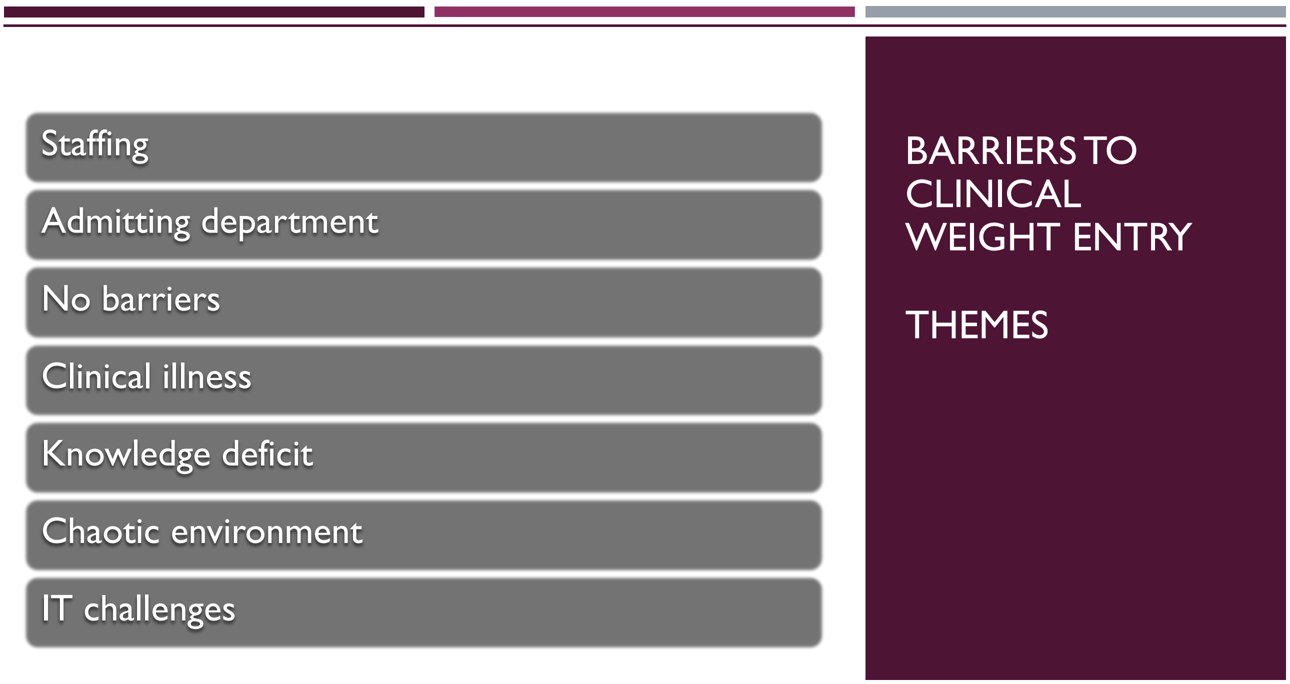
Note: Nursing survey correlations. Data analysis with SPSS (2022).

Appendix R

Barriers to Clinical Weight Entry Themes

Table R3

Themes for barriers to clinical dosing weight entry in order of frequency reported



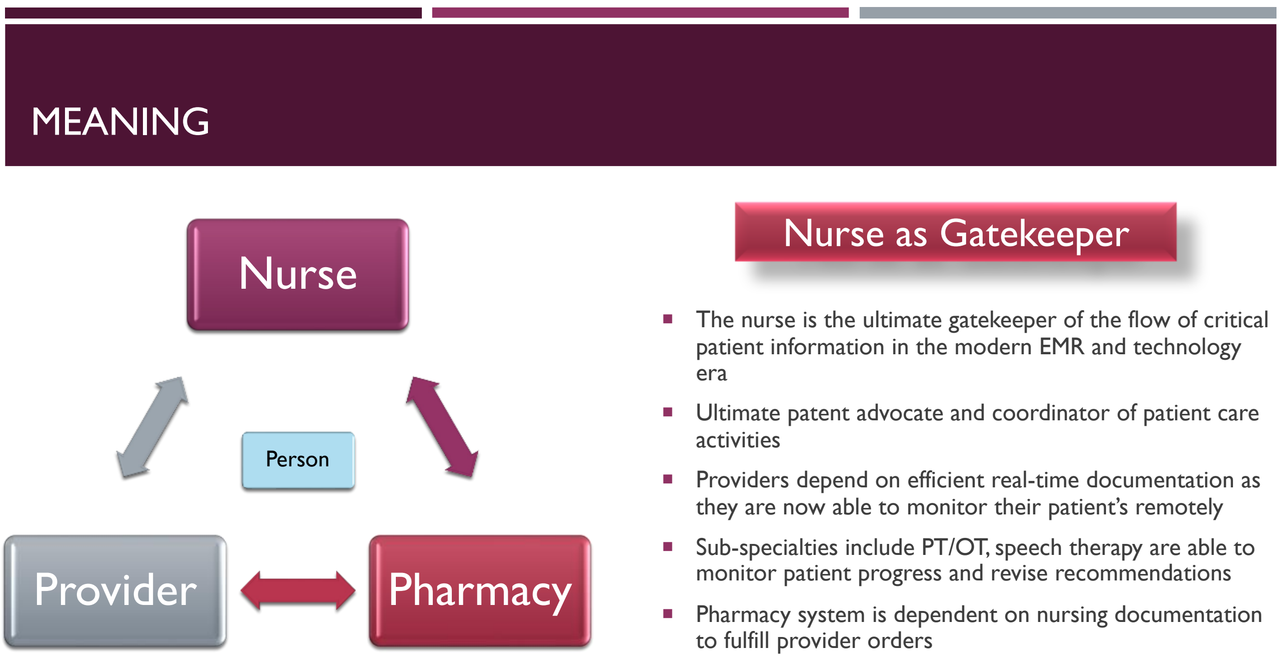
Note: Nursing survey qualitative themes developed for barriers to clinical dosing weight documentation.

Appendix S

Nurse as Gatekeeper

Figure S1

Visual representation of the nurse as gatekeeper.



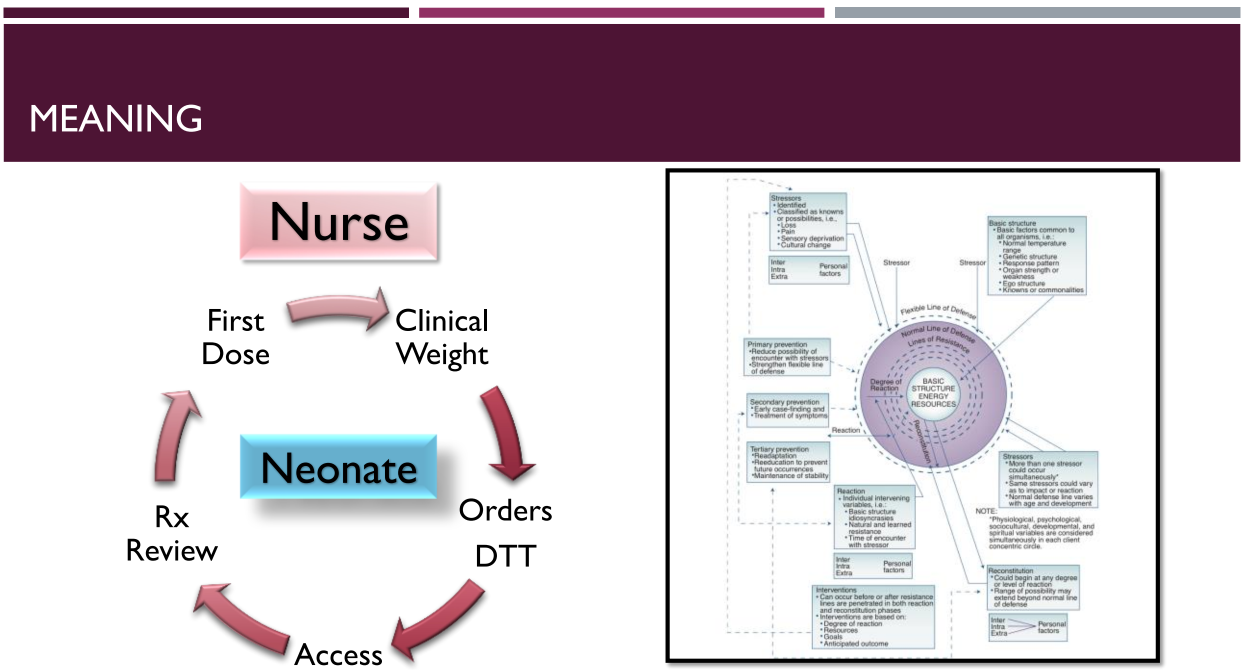
Note: Proposed nurse as gatekeeper concept application to practice problem

Appendix S

Application of Nursing Theory

Figure S2

Visual representation of the NICU nurse and Neuman's System Model application



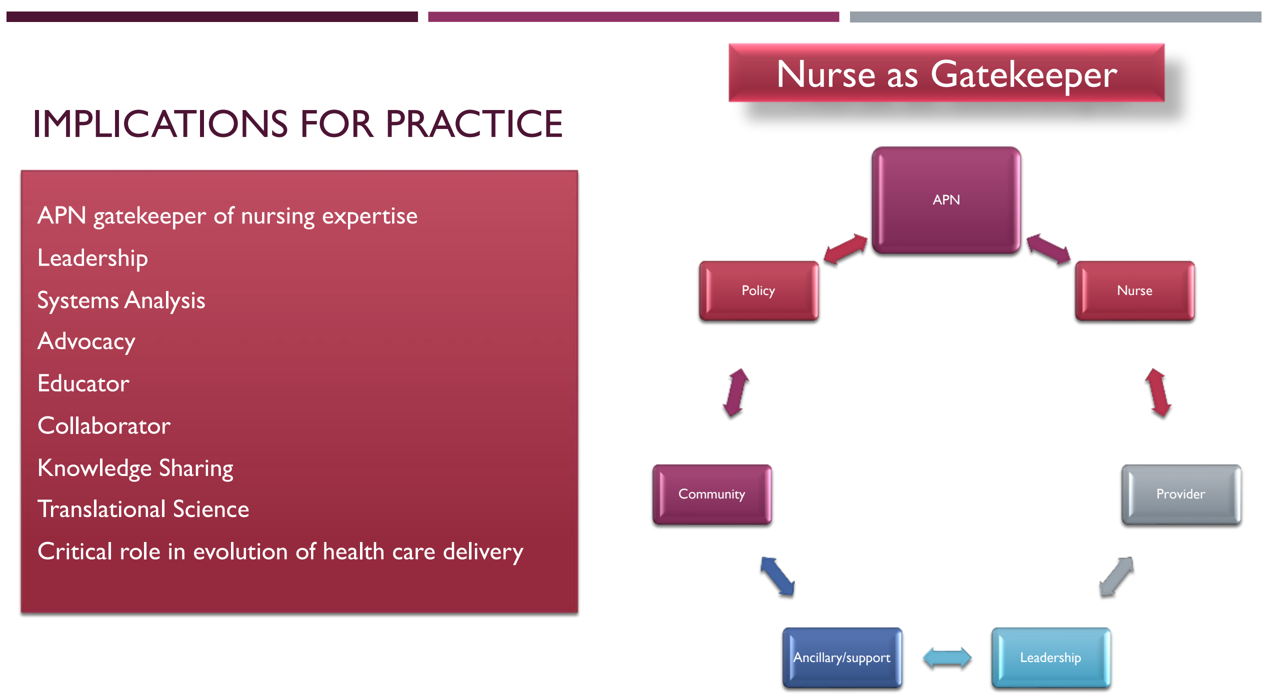
Note: NICU nurse building new lines of defense surrounding neonate congruent with system's model application.

Appendix S

Advanced Practice Nurse Gatekeeper

Figure S3

Visual representation of the APRN and contribution to practice through nursing expertise



Note: The APRN gatekeeper for the evolution of health care delivery