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Prevention of Methicillin-Resistant Staphylococcus Aureus in Neonatal Intensive Care Units: A Systematic Review

Abstract: *Methicillin-resistant Staphylococcus aureus (MRSA) is a leading cause of healthcare-associated infections (HAI). Infants in Neonatal Intensive Care Units (NICU) are at increased risk for infection with MRSA. Colonized parents, healthcare workers and other infected neonates are primary sources contributing to the spread of MRSA. Adherence to strict hand hygiene, proper use of personal protective equipment (PPE), surveillance, patient education, and communication between regional NICU are proven most effective in reducing the spread of MRSA in the NICU. Systematic searches of Cumulative Index of Nursing and Allied Health Literature (CINAHL) Complete and PubMed (MEDLINE) were conducted to collect data concerning MRSA prevention in the NICU, since 2010. The most common facilitators included hand-hygiene compliance, active surveillance throughout the infant's stay in the unit, and compliance with strict prevention policies. The most common barriers included perceptions of pertinent personnel, external risk factors, and cost. The information collected articulates the weaknesses of current practices that led to the conclusion that measures set in place are not enough to prevent the spread of MRSA in NICU. Prophylactic measures, as well as education, are necessary in order to minimize the rate of infection. Effective and appropriate treatment of neonates is emphasized, and the conclusions are useful to decision-makers seeking to implement better practices, or improve practices currently set in place.*

Key Words: *Methicillin-Resistant Staphylococcus Aureus, MRSA, Neonate, Infection, Prevention, Nursing Practice, Risk, Mitigation*

BACKGROUND AND SIGNIFICANCE

Healthcare-Acquired Infections (HAI)

Healthcare-acquired infections (HAI) are one of the most significant causes of death and illness among infants and premature neonates. Among those HAI, MRSA infection is significant among NICU patients (Navarro, Pekelharing-Berghuis, de Waal, & Thijsen, 2011). The Centers for Disease Control and Prevention (CDC) estimate that approximately 1.7 million HAI occur in United States (US) hospitals every year, including more than 33,000 cases in the NICU (Klevens, Edwards, Richards, Horan, Gaynes, Pollock, & Cardo, 2007). The incidences of late-onset MRSA infections in NICU increased more than 300% from 1995 to 2004 (Milstone, Song, Coffin, & Elward, 2010). Methicillin-resistant *Staphylococcus aureus* in the NICU may be acquired from colonized parents, healthcare workers (HCW), and other neonates often resulting in poor outcomes and long-term sequelae (Carey, Della-Latta, Huard, Wu, Graham, Carp, & Saiman, 2010; Maree, Miller, Daum, Boyle-Vavra, & Matayoshi, 2007; McAdams, Rajnik, Ellis, & Trevino, 2008). Neonates who are exposed to MRSA shortly after birth can become colonized quickly after contact with adult skin or the environment (Nelson, & Gallagher, 2012). Methicillin-resistant *Staphylococcus aureus* colonization or infection in neonates is associated with significant morbidity, and the cost of medical treatment for these infants carry a high financial burden (Huang, Chou, Su, Lien, & Lin, 2006). Interventions have been implemented to minimize the transmission of MRSA in the healthcare setting including screening high-risk patients upon admission and using proper hand hygiene by healthcare workers (Buick, Joffe, Taylor, & Conly, 2015; Chiu,

Michelow, Cronin, Ringer, Ferris, & Puopolo, 2011; Huang, Septimus, Kleinman, Moody, Hickok, Avery, ... & Hayden, 2013; Papia, Louie, Tralla, Johnson, Collins, & Simor, 1999). Despite these measures and precautions being rigorously enforced, ongoing MRSA transmission and infection have been recorded for many years (Calfee, Salgado, Milstone, Harris, Kuhar, Moody, ... & Yokoe, 2014; Dantes, Mu, Belflower, Aragon, Dumyati, Harrison, & Ray, 2013).

Precautions for Spread of MRSA in NICU

Precautions currently set in place in NICU facilities seek to reduce the rate of infection among patients by implementing preventative practices that quarantine those who have tested positive, while maintaining strict hygiene practices for both patients and healthcare workers. Preventive measures include healthcare workers hand hygiene, environmental cleaning, and occasionally, the decolonization of colonized neonates (Pierce, Lessler, & Milstone, 2015; Septimus, & Schweizer, 2016).

The lack of complete adherence to preventive practices allows MRSA to continue to be a significant cause of morbidity in NICU. Understanding that many healthcare workers can be carriers for MRSA serve to increase the methods set in place to prevent transmission from them to neonate. Preventive measures serve to reduce the transmission from HCW who may carry the infection from one neonate to another, while addressing those other adults who come into contact with neonates who may be carriers themselves.

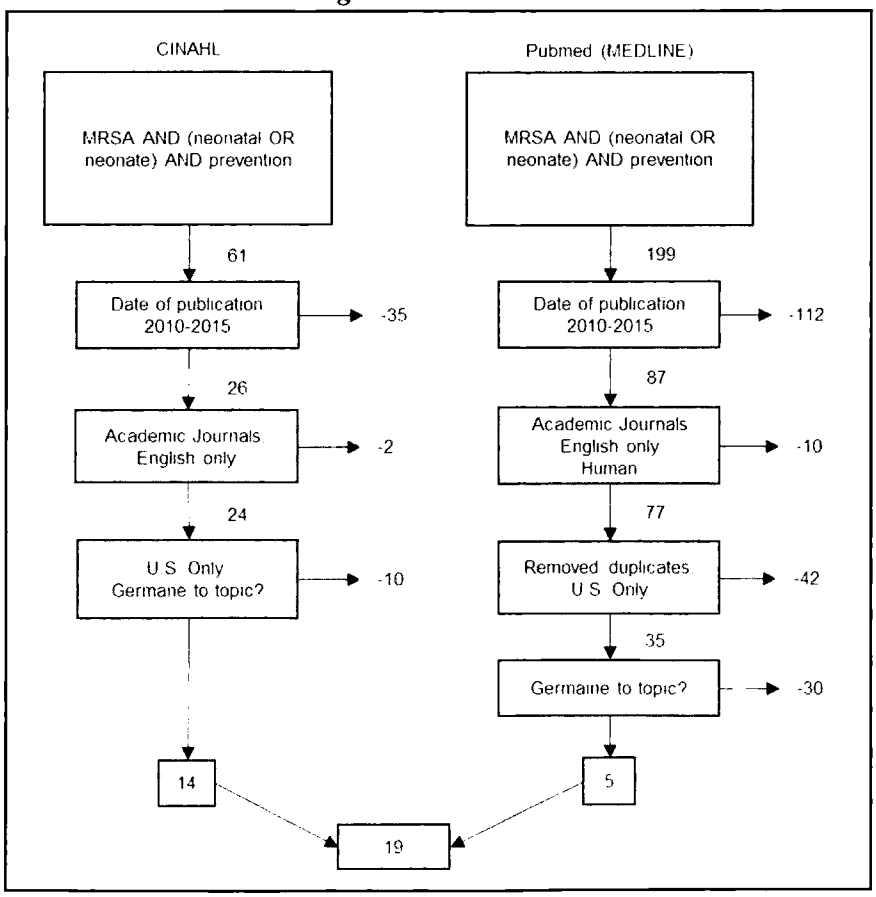
Impact of Surveillance

Diligent surveillance of individuals both prior to recognition of MRSA and after, are important in effectively preventing and managing the disease. In terms of surveillance, data have shown that the vast majority of neonates do not test positive for MRSA on NICU admission screenings. This evidence serves to further address the importance of prophylactic measures throughout the course of patient care, and also serves to further the notion that screening of parents of infants requiring NICU care may be a useful adjunct to increase surveillance measures currently set in place (Sullivan & Goodier, 2015).

Impact of Infection Control Practices

Infection control practices in the NICU setting include policies and procedures that pertain to all persons present throughout the course of patient care. Infection control practices serve as an effective foundation against MRSA transmission and occurrence, but must be strictly adhered to in order to be successful. Preventive infection control practices such as hygiene and screening can also serve to reduce the amount of antibiotics required. Evaluation of potential reservoirs of bacterial acquisition and transmission may serve as some of the most valuable

Table 1: PRISMA Flow Diagram



tools when preventing neonatal MRSA infection (Zervou, Zacharioudakis, Ziakas, & Mylonakis, 2014).

The findings of this review may be useful to hospital Infection Prevention (IP) Teams and NICU staff members interested in controlling and preventing the spread of MRSA. It may also assist in identifying barriers to overcome and opportunities to improve quality of service. Policymakers may also find the identified factors useful when attempting to reduce spread of MRSA. Researchers may also utilize this information in the design of studies conducted to show inventive ways to reduce the incidence of MRSA in the NICU.

METHODS (DATA AND SAMPLE)

Data for this review were gathered using two separate databases: Cumulative Index of Nursing and Allied Health Literature (CINAHL) Complete via Elton B. Stephens Company (EBSCO Host), and PubMed (which queries MEDLINE). Search criteria focused on MRSA, neonates, and prevention. Articles were reviewed and identified during the search and were independently summarized. Articles were only included if selected by at least two reviewers.

Beginning the examination process, there was a well-defined database search. Several exclusion criteria were utilized within the research databases in order to narrow search results to only those articles considered relevant to this study. This method avoided the inclusion of data too broad to provide valuable information for analysis. Searches were limited to peer-reviewed articles written in the English language, published from 2010 through 2015 (n=19). See Table 1).

After the selection of articles relevant to the literature review, a comprehensive table of findings was created to summarize the facilitators and barriers of each article. A thorough process was used to remove unrelated or duplicate materials from the final data. The conclusions drawn from each article are summarized (See Table 2).

An overall analysis of the articles included in the literature review revealed multiple facilitators and barriers to MRSA prevention that appeared on a consistent basis. The literature review focused specifically on the facilitators and barriers pertaining specifically to NICU. Inclusion of the term "NICU" and any derivatives of it caused exclusion of many pertinent articles. Preventing the spread of MRSA in NICU included hand-hygiene compliance, active-surveillance throughout the infant's stay in the unit, compliance with strict prevention policies, and rapid intervention. The barriers of preventing the spread of MRSA in NICU included perceptions of pertinent personnel, external risk factors, cost, and a lack of research in regard to the effects of MRSA in NICU.

During the five-year period assessed by this systematic literature review, 19 works were published that studied, analyzed, or discussed issues surrounding MRSA and how it might be spread in the NICU. Most works highlighted both facilitators and barriers. Eighty-

Table 2: Results from the Literature Review

Authors (by year, descending)	Facilitators of Prevention	Barriers to Prevention
Asarian, et al.	**Direct admission of neonates to the NICU, eliminating the referring hospital to reduce the spread of MRSA** **Whole-genome sequencing provide improved turnaround time for diagnostic purposes with the added benefit of enhanced surveillance, outbreak detection, and investigation**	**Whole-genome sequencing alone cannot replace the need for surveillance and epidemiological investigation** **Whole-genome sequencing technology is not readily available in all clinical laboratories**
Kaushik, et al.	Cohorting of neonates who have tested positively in regards to real-time nasal testing. From there, susceptibility testing was conducted and were then differentiated by susceptibility	Because of the retrospective nature of part of the study, genotyping of MRSA isolates could not be performed. Isolation was thus performed as "likely to be CA-MRSA, etc."
Carey, et al.	**Adoption of prophylactic measures and aggressive strategies are highly effective in reducing the rate of infection**	**Lack of information for neonates can prove controversial. Indistinguishable MSSA and MRSA create complications, and constant bacterial change as a result of antibiotic overuse**
Hocevar, et al.	Contact precautions for patients with MRSA, assessing the need of a central line daily for removal when not necessary, performance of hand hygiene prior to central line use, education for all people inserting central lines, and use of maximal barrier precautions when inserting a central line can reduce spread of MRSA	Centers for Disease Control and Prevention (CDC) recommendations for bundle implementation state that the components of the bundle should be both evidence based and cost-effective, which can prove difficult in NICU patients, given the paucity of evidence for some practices
Nelson et al.		**Infants and adults do not have the same outcomes when treated with the same therapies** **The efficacy and safety of treatments initially tested on adults need to be validated in infants and children prior to widespread utilization.** **Widespread use of universal decolonization strategies employing mupirocin and chlorhexidine in NICUs could lead to the development of antimicrobial resistance** **Additional trials are needed to evaluate the efficacy, safety-both short and long-term, and cost effectiveness of education initiatives, surveillance programs, and decolonization strategies, as well as longitudinal trends in colonization, invasive infection, and patterns of antibiotic susceptibility**
Lee et al.	Rapid transmission pattern of the outbreak assisted in recognizing the problem early enough to implement multiple infection control measures within a short period of time	Chlorhexidine show higher rate of skin reactions in neonates with birth weights of less than 1500 g in NICU Contamination of healthcare workers' PPEs with multidrug-resistant organisms could be sources of further transmission
Popoola et al.	**Routine surveillance cultures, private rooms or cohorting and contact precautions, decolonization of infants and healthcare workers (HCWs), and increasing hand hygiene compliance can reduce spread of MRSA in neonates**	**The interval between colonization and infection in many neonates was short (median, 5 days), suggesting a narrow window of opportunity for intervention in colonized neonates to reduce the risk of subsequent infection** **Neonates who received decolonization treatment became recolonized during their NICU stay**
Song et al.	Improving hand hygiene practice among health care providers could further reduce MRSA acquisition risk in NICU patients	Hand hygiene compliance by healthcare providers remains universally low
Stoccese, S. et al.	**Central line-associated infections and similar device-associated infection rates in NICUs were compared to that of general hospital admissions. Evidence found that neonates with lower birth weights were significantly more susceptible to CAIs**	**Susceptibility of neonates prohibits complete implementation of preventative practices against MRSA, etc., because of the neonate's vulnerable immune systems**
Nelson & Gallagher	Increased rates of hand washing and screening patients for MRSA at admission are the most effective strategies to reduce rates of MRSA transmission among hospitalized patients Isolation reduce spread of MRSA Open communication between regional NICUs is essential to prevent spread of MRSA between NICUs when patients are transferred to different institutions	Low birth weight has been associated with increased risk of MRSA colonization Prematurity and younger gestational age is also a risk factors for MRSA colonization Feeding methods are associated with higher risk of MRSA infection
Duffy et al.	**Screening, hand washing, cohorting and decontamination may be effective throughout this period in order to avoid colonization**	**Surveillance sampling is not effective at identifying all infants at risk of bacteremia**
Shane, et al.	There is equivalent morbidity and mortality among MRSA and MSSA in low birth weight and very-low birth weight infants, showing that allocation of resources amongst the two should be comparable	Although there is no statistical difference among infants with very-low birth weights and low birth weights in regards to infection, mortality for these neonates is still abnormally high as compared to the rest of the population. This indicates a need for stricter prevention methods in order to reduce the rate of infection
Beigi et al.	**Prevalence of MRSA colonization among pregnant women is low. The rate of vertical transmission of MRSA from mother to newborn is also low**	**Further research is needed to fully understand the risks of colonization and transmission, and the optimal antibiotic regimens for treatment of infection among pregnant and lactating women**
Chiu, et al.	Reduction in unnecessary exposure to vancomycin Substitutions and stricter guidelines for vancomycin use require healthcare workers to contemplate the benefits and effects of vancomycin use instead of approvable substitutions	There is a lack of information on the long-term effects of vancomycin restriction on the health of NICU patients and microbial ecology
Scheuer	**Successful programs for control of MRSA can save millions of dollars in avoidable costs**	**Challenges lie in the area relates to staff and family education about contact precautions, purchase of additional isolation carts and core practice of strict hand hygiene**
Song et al.	Blanket mupirocin decolonization was successful for decolonization of MRSA in neonates and young infants	Polymerase Chain Reaction (PCR)-based MRSA screening is costly
Sakamoto et al	**Increasing the amount of alcohol-based hand sanitizer usage by improving accessibility and providing periodic hand hygiene training sessions to health care workers was associated with a statistically significant and sustained downward trend in MRSA incidence density rates in NICU**	**Ensuring that NICU staff and visitors perform hand hygiene upon entry into the NICU**
Milstone et al.	Active surveillance culturing for MRSA carriers in combination with isolation and decolonization can reduce MRSA transmission and MRSA infection rates	Most MRSA control guidelines do not account for the NICU's unique patients and environment
Murillo, et al.	**Pulse-field gel electrophoresis utilized to genotype MRSA in infants. Additional control measures included contact isolation of infected and colonized babies, unit-wide cleaning program, and infection control education with particular attention to hand hygiene before and after patient contact. Weekly meetings with the NICU staff were held to assess adherence to the infection control measures**	**The process of admission into the NICU can actually introduce MRSA to infants. Although real-time testing comprised of a nasal swab can provide results, the admission process still poses significant threat to vulnerable individuals**

Table 3: Facilitating Themes Associated with Decreasing MRSA Infections in the NICU

Affinity Matrix

Facilitators	Total Number	Percentage
Active-surveillance	8	18%
Hand-hygiene compliance	7	16%
Improved health outcomes	6	13%
Intervention	6	13%
Cohorting amongst populations	5	11%
Strict prevention policies	4	9%
Cost savings	3	7%
Technology/Equipment	3	7%
Education	2	4%
Communication between	1	2%
Total	45	

two factors were determined as facilitators or barriers overall. There were 45 facilitators identified (54.8%) and 37 barriers identified (45.2%).

Facilitators

The most common facilitators in prevention of MRSA in NICU departments included routine screening of neonates and the mother, elimination of the referring hospital, direct admission of the patients to the preferred hospital's NICU department, use of whole-genome sequencing for diagnostic purposes, adherence to strict hand hygiene, shortening the length of stay of patients, and open communication between regional NICU departments. In addition, utilization of active surveillance to detect colonized infants earlier allows prophylactic measures to reduce the rate of infection. Increasing the amount of alcohol-based hand sanitizer usage by improving accessibility and providing periodic hand hygiene training sessions to health care workers along with the use of PPE, contact precautions for patients with MRSA, and implementing education initiatives related to prevention of MRSA may create an environment in which MRSA cannot spread.

Prophylactic measures currently set in place are effective when adhered to appropriately. Screening methods vary widely through facilities, but ultimately seek to identify infected patients and remove them from the population of uninfected patients to reduce the likelihood of transmission. Preventive screening measures, along with appropriate sanitation practices were found to be the most effective methods of reducing the rate of transmission.

Healthcare organizations recognize the need to improve the quality of care while avoiding these preventable costs. This situation creates an incentive for organizations to reduce the rate of infection among its patients. The benefits of adhering to preventive measures benefit both the organization and its patients, helping the organization maximize its profits while reducing the rate of preventable readmissions (See Table 3).

Barriers

The most prevalent barriers include overcrowding of patients, understaffing, overuse of antibiotics, and long-term indwelling intravenous catheters. Some surveillance technologies are costly and not readily available in most hospitals, which further increase the chances of MRSA infection, also included are low birth weight, prematurity and feeding methods. Other barriers included poor staff and family education in regard to contact precautions, purchase of additional isolation carts, and core practice of strict hand hygiene. Finally, treatment of infants with the same procedures used to treat adults, increase the prevalence of MRSA. Information has found that even through epidemiological assessment of transmission patterns and implementation of strategies for prevention, MRSA remains a significant source of morbidity in the NICU population. Neonatal Intensive Care Units may identify this loophole in strict prophylactic measures with the continuing infection and attribute preventable infections to said loophole.

Table 4: Barrier Themes Associated with Decreasing MRSA Infections in the NICU

Affinity Matrix

Barriers	Total Number	Percentage
Lack of research/technology	7	19%
External risk factors	6	16%
Unit Characteristics	5	14%
Weight of Neonate	4	11%
Cost	3	8%
Perceptions	3	8%
Time Issues	3	8%
Antibiotic overuse	3	8%
Poor hand-hygiene compliance	2	5%
Recolonization	1	3%
Total	37	

The prevalence of human carriers of the disease creates the perfect environment in which a lack of strict adherence can propagate MRSA infection. Treatment of neonates with the same treatments as adults does not generate similar outcomes, which further serves to compromise the infant's immune system. Current widespread measures set in place to handle nosocomial infections do not all have sufficient support to justify their implementation in a NICU (See Table 4).

DISCUSSION

Many factors attribute to the spread of MRSA in the NICU, such as cost, perceptions and the implementation of strict policies. Further analysis of the extent to which each of these factors can be manipulated may prove beneficial for persons interested in improving outcomes related to the infants placed in the NICU.

Decreasing MRSA Incidence

The theme from the facilitators mentioned most often was active-surveillance (Azarian, Cook, Johnson, Guzman, McCarter, Gomez, ... & Salemi, 2015; Duffy, Garbash, Sharland, & Kennea, 2012; Hocevar, Lessa, Gallagher, Conover, Gorwitz, & Iwamoto, 2014; Kaushik, Kest, Zauk, DeBari, & Lamacchia, 2015; Lee, Kim, Choi, Seo, Shin, Bok, ... & Song, 2014; Milstone, et al., 2010; Nelson & Gallagher, 2012; Shane, Hansen, Stoll, Bell, Sánchez, Shankaran, ... & Newman, 2012). This theme was identified 8 out of 45 total occurrences (18%). The need for active prophylactic measures as a common theme in this area, were noted. Enhanced surveillance and detection, along with aggressive prophylactic measures were shown to be able to decrease overall MRSA incidence in neonates.

Hand-hygiene compliance was also noted quite often as a facilitator in the prevention of MRSA in 7 of 45 occurrences (16%) (Duffy, et al., 2012; Hocevar, et al., 2014; Murillo, Cohen, & Kreiswirth, 2010; Nelson & Gallagher, 2012; Popoola, Budd, Wittig, Ross, Aucott, Perl, ... & Milstone, 2014; Sakamoto, Yamada, Suzuki, Sugiura, & Tokuda, 2010; Song, Stockwell, Floyd, Short, & Singh, 2013). A common theme among these articles surrounded healthcare workers compliance with hand-hygiene procedures, as well as parents and other visitors to the NICU.

Interventions and cohorting were common themes in the literature. Intervention was measured in 6 of 45 (13%) articles, whereas cohorting was mentioned in 5 of 45 (11%) articles. Each of these areas dovetailed into each other as cohorting itself could be an overall intervention. It was separated from interventions as it was a specific measure of intervention. Cohorting of neonates who were positive for MRSA, allowed healthcare workers to easily identify those who needed contact precautions, and for a much easier signaling mechanism for those workers to be alerted to the special needs of this population. Neonates are much more susceptible to other infections as well as complications from lower weight overall (Hocevar, et al., 2014). By having these signaling mechanisms in place, effective strategies were seen to decrease the transmission of MRSA among neonates who are hospitalized.

Lastly, strict intervention policies (9%) (Carey, 2014; Hocevar, et al., 2014; Murillo, et al., 2010; Song,

Cheung, Klontz, Short, et al., 2010) and education (4%) (Murillo, et al., 2010; Sakamoto, et al., 2010) were shown to be important facilitators in preventing the spread of MRSA in the NICU. Intervention policies were focused on decreasing carriers of MRSA and in decolonization of affected patients. These same policies were often focused on parents and limiting their access to the neonates, if they themselves were positive carriers for MRSA.

Population

Many population controls identified were also being focused in the area of barriers, increasing the spread of MRSA in the NICU. However, two facilitators were identified, which were cohorting among populations (5%) and strict prevention policies (9%). Both of these areas focused on keeping those with MRSA together to minimize exposure to others.

The focus of population controls in the literature was in the area of barriers. External risk factors were the barrier most often mentioned in this area in 6 of 37 (16%) articles (Beigi, 2011; Carey, 2014; Hocevar, et al., 2014; Nelson & Gallagher, 2012; Sakamoto, et al., 2010; Scheans, 2010).

A key point was the understanding that neonates and adults have much different risk factors for the spread of this disease. Individuals who would most benefit from prophylactic measure implementation would be the neonates, whose immunocompromised conditions may leave them susceptible to further sequelae (Hocevar, et al., 2014). The detrimental effects of poor preventive screening measures and poor hygiene practices can have neurological implications on neonates that could affect development and growth (Popoola, et al., 2014).

Organizational implications to increase preventative measures include quality of care and the high costs associated with subsequent treatment for nosocomial infections. Prophylaxis is critical due to the long-term effects that even the most appropriate therapy can have on patients. Thus, the burden of nosocomial infections is as much a burden on a neonate's caregivers as it is on the healthcare facility. The importance of preventative measures cannot be overemphasized (Popoola, Budd, Wittig, Ross, Aucott, Perl, ... & Milstone, et al., 2014).

Cost

The costs to implement effective preventive measures in the NICU seek to reduce the rate of MRSA infection are outweighed by the cost to readmit NICU patients (Song, et al., 2010). The differences in the treatment of NICU patients further drive up the costs to treat patients who have contracted a nosocomial infection. These costs serve as an incentive for organizations to increase their prophylactic measures to reduce the costs incurred once a nosocomial infection is contracted.

Perceptions

A main factor to consider when seeking a reduction in the rate of transmission of nosocomial infections in the healthcare setting is the perception of transmission of any individual present in the healthcare organization. Because the organism can spread quickly and even progress without detection, it is important to detect colonization as early as possible to reduce the rate of patient-to-patient transmission (Nelson, Bizzarro, Dembry, Baltimore, & Gallagher, 2014; Sakamoto, Yamada, Suzuki, Sugiura, & Tokuda, 2010). A lack of education on how easily MRSA spreads can create the perfect environment for transmission of disease.

A healthcare organization will face the costs of nosocomial infections, while the infected will have to suffer the consequences. Because of this, healthcare organizations have a cost-driven incentive to reduce the rate of infection while also striving to maintain the quality of the care provided.

Implementation of Strict Hand Hygiene Policies

Implementation of strict hand hygiene policies requires diligent and consistent practices. In order to significantly reduce the rate of transfer of nosocomial infections through hand-to-patient exposure to infection, hygiene practices must be strictly adhered to be effective. Evidence has shown that among colonized healthcare workers, their hands were likely the mode of MRSA transmission (Scheans, 2010).

Other Facilitators

Strict hand hygiene policies, in conjunction with comprehensive MRSA control programs reduce the transmission of MRSA from healthcare workers to neonates. These hygiene procedures serve to reduce the rate of infection among those neonates whose immune systems may still be developing and vulnerable to infection. The importance of strict hand-hygiene policies cannot be overemphasized.

MRSA's long-term sequelae, including poor neurodevelopment and growth, can be significant enough to follow through with strict hand hygiene policies. The organization has a duty to implement strict hand hygiene policies for both quality of care and cost of subsequent treatment because of the nosocomial infection (Popoola, et al., 2014).

Other Barriers

This review has attempted to articulate the methods of MRSA transmission in NICUs. Treatment of neonates with adult regimens, poor hygiene procedures and screening procedures, serve to propagate MRSA and maintain its presence in NICU facilities. These barriers, along with a misunderstanding of the importance of proper hand-hygiene practices with anyone who is exposed to NICU patients), are at fault for the MRSA loophole, which prevent its eradication (Nelson & Gallagher, 2012).

CONCLUSIONS

It is important to analyze the factors contributing to the spread of MRSA in NICU, because it reveals the

need for additional prophylactic measures within this specialized care unit. A systematic evaluation of a select group of articles provided information for this study in which factors and barriers to the prevention of MRSA were identified. It is inferred that the derived information will prove useful for NICU staff, IP teams and decision-makers who are in search of opportunities to improve outcomes, implement effective measures, and lower costs related to HAI in the NICU.

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