A Novel In Situ Simulation Intervention Used to Mitigate an Outbreak of Methicillin-Resistant *Staphylococcus aureus* in a Neonatal Intensive Care Unit

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Objective To describe the successful implementation of an in situ simulation program to diagnose and correct latent safety threats in a level 4 neonatal intensive care unit (NICU) to mitigate a methicillin-resistant *Staphylococcus aureus* (MRSA) outbreak.

Study design An investigational report describes a simulation intervention that occurred during a 4-month MRSA outbreak in a single-center, 46-bed, newly renovated level 4 NICU. The simulation program was developed for all NICU providers in which they were exposed to a 30-minute in situ human simulation intervention that included education, evaluation, and debriefing to resolve perceived or observed latent safety threats. The primary study outcome was improved hand hygiene compliance and an enhanced estimate of the culture of safety during a 6-month period.

Results A total of 99 healthcare providers including physicians, nurses, respiratory therapists, and environmental service workers completed the course. Before the simulation intervention, there were 18 patients colonized or infected with a single MRSA clone; after the intervention, there were no new episodes of colonization or infection.

Conclusions An in situ, simulation-based intervention can counter threats to patient safety related to workflow and lapses in infection control practices and improve patient outcomes. *(J Pediatr 2017;■■:■■-■■).*

Hospital-acquired infections (HAIs) are a common cause of morbidity and mortality, and prevention is one of the Joint Commission on Accreditation of Healthcare Organizations national patient safety goals.[1] Outbreaks of resistant bacteria are reported more frequently in neonatal intensive care units (NICUs) compared with other intensive care units, and methicillin-resistant *Staphylococcus aureus* (MRSA) often is the causative pathogen.[2] The etiology of HAIs is multifactorial and patient, provider, and system factors contribute to their development.

Suboptimal infection control practices, patient workload, as well as the culture of safety have been implicated in hospital outbreaks of resistant bacteria.[3] Assessments of workflow have been used previously to identify barriers to infection control practices.[4] As more NICUs move from an open floor plan design to smaller, compartmentalized pods or rooms, the shift in workflow, particularly for nursing staffs, may lead to multiple unintended latent safety threats that could affect infection control processes. A latent safety threat has been defined as "errors in design, organization, training, or maintenance that may contribute to medical errors and have a significant impact on patient safety."[5]

Although hand hygiene is considered essential in preventing HAIs, compliance with hand hygiene remains a challenge, and adherence rates often are less than 50%[6-11] Identifying barriers to hand hygiene compliance is critical and has included knowledge related to existing guidelines, as well as environmental influences such as the placement of sinks or alcohol-based gel dispensers relative to the bedside.[12,13]

Simulation-based training has been used in healthcare for more than a decade as a tool to improve patient safety.[14-17] Although simulation-based studies have shown evidence of improved technical skills, teamwork, and crisis resource management, evidence of improved patient outcomes remains sparse.[18-20] In situ simulation (taking place in the actual patient care setting/environment) has been used to identify latent safety threats that may predispose to medical errors and subsequent patient harm.[5,21-23] Allowing practitioners and support staff the opportunity to participate in simulation scenarios within their actual work environment provides a means to probe the workplace for latent safety threats (including suboptimal interpersonal and communication skills, technical skills, and environmental resources); once identified, these threats can be corrected.[24]

HAI	Hospital-acquired infection
MRSA	Methicillin-resistant *Staphylococcus aureus*
NICU	Neonatal intensive care unit

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Three months after moving into a newly built NICU with a compartmentalized pod plan, we experienced an outbreak of MRSA, with a total of 18 infants either colonized or infected with a single clone of MRSA over a period of 12 weeks. Published recommendations focused on infection control practices to control a MRSA outbreak were implemented yet failed to prevent new cases from occurring.[25] Based on the timing of the MRSA outbreak with the move to the new NICU, the altered environment and workflow were identified as potential causative factors. An in situ simulation-based intervention was designed and implemented with follow-up to assess success.

Methods

This report was reviewed and approved by the Pediatric Performance Improvement Review Oversight Committee at Mount Sinai as a quality improvement project exempt from institutional review board review. The new Mount Sinai Hospital NICU is a 46-bed, level 4 New York State Regional Perinatal Center. Construction of the new NICU was planned in 2 phases with a combination of pods and single-patient rooms. Construction in the first phase was complete when the outbreak occurred; these rooms were composed entirely of pods. Two pods comprised a room and were designed to hold up to 4 patients (**Figure 1**, A; available at www.jpeds.com).

The previous NICU floor plan was quite different. The unit was constructed to hold up to 35 patients and featured an open floor plan design with as many as 10-15 patients located in a given section. Two large rooms held the majority of patients; 5 additional smaller rooms held between 2 and 4 patients. This configuration allowed for uninterrupted line of sight between practitioners and patients; easy verbal communication between nurses, physicians, and support staff; and streamlined protocols for handling the flow of patients and equipment (**Figure 1**, B).

Initial Interventions in Response to the Outbreak

Before the outbreak, NICU practice was to place all MRSA-colonized patients on contact precautions but not necessarily in a single isolation room, and routine surveillance for MRSA only occurred for infants transferred in from outside hospitals. Once the outbreak was identified, all MRSA-colonized patients were cohorted together in 2 pods. All other infants had specimens for screening cultures obtained on admission and weekly. Surveillance cultures were obtained from the nares, axilla, and umbilicus via a single culture swab for each infant. For patients who were mechanically ventilated, respiratory cultures also were obtained on admission and weekly. Surveillance cultures were performed until there were 3 consecutive weeks with all cultures negative for MRSA. Per hospital-wide routine practice initiated 3 months before the outbreak, hand hygiene was monitored and just-in-time coaching was provided to practitioners who failed to perform infection control measures.

The goal of cohorting patients and staff was to limit ongoing environmental colonization as MRSA also was isolated from swabs of environmental surfaces (incubators and a shared equipment container). A pool of nurses was identified to care only for MRSA-colonized patients. Nurse-to-patient ratios both for MRSA-colonized and noncolonized infants remained unchanged before, during, and after the outbreak and varied based on acuity and census. Nurses caring for critically ill infants were assigned 1-2 patients; nurses caring for less acutely ill infants were assigned 3-4 patients. A deep terminal cleaning of the NICU was performed at week 5 of the outbreak to reduce the bio-burden throughout the unit.[26]

At week 9 of the outbreak, given that the standard methods mentioned previously had failed to eliminate the MRSA bioburden from the unit, the decision was made to use simulation as a method to re-educate clinical and support staff regarding existing infection control policies and potentially identify how the new workspace/workflow might be contributing to lapses. A simulation team of 3 anesthesiologists was recruited to lead the simulations. They were identified as they had recently completed a well-received simulation program during the development of the policies and procedures needed to maintain an isolation unit for a patient with a suspected Ebola infection. The timeline of events is illustrated in **Figure 2**.

Simulation–Based Interventions

Before the simulation team intervened, no practitioners underwent simulation in the old or new unit to test the workflow. Initially, the simulation team observed all types of providers in the unit (including nursing staff, medical team, respiratory therapists, and environmental service workers) to determine practices and to identify potential latent safety threats. The report of their findings is seen in **Appendix 1** (available at www.jpeds.com).

After the observation phase was completed, new workflow protocols were created to address the identified latent safety threats. Nursing champions were identified from the senior staff members in the unit and together the nurses and simulation team used the simulators to test all of the newly created protocols and ensure compatibility with the daily workflow needs of the unit. Corrections were made as necessary. The team created a course to educate and train the entire NICU staff. For the educational scenario, simulator mannequins were covered in an ultraviolet luminescent spray (Glo Germ; Glo Germ Company, Moab, Utah) that would allow tracking of the surfaces the staff had touched and subsequently "contaminated" (**Appendix 1**).

Over a period of 2 weeks, a total of 99 providers in groups of 3 participated in 30-minute interdisciplinary in situ simulations; the majority (n = 83) of providers were nurses. Others included NICU physicians, housestaff, consultants, and respiratory therapists. The in situ simulations occurred in one of the pods within the NICU. Each member of the team was given a specific role, ie, primary caregiver, charge nurse, and observer. The scenario included the care of 2 patients, an intubated infant born premature and an infant with hypoglycemia born at term. The primary nurse was presented with challenges that arise daily in the NICU, including responding to a suspected unplanned extubation, alarming medication pump, and an infiltration of a peripheral intravenous catheter. The

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