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Nurse-Driven Care in the Pediatric Intensive Care Unit: a Review of Recent Strategies to Improve Quality and Patient Safety

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Opinion statement

Hospital-acquired infections define a problematic complication for pediatric patients being treated in the pediatric intensive care unit (PICU). Most importantly, hospital-acquired infections are associated with significant risk of morbidity and mortality. Additionally, the Center for Medicaid Services has invoked a non-payment policy for some preventable conditions which include health care-acquired infections. Pressure ulcers (PUs), catheter-associated urinary tract infections (CAUTIs), central line-associated bloodstream infections (CLABSIs), and ventilator-associated pneumonia (VAP) are some of the many hospital-acquired infections (HAIs) for which patients are at risk. Though physicians typically chair many of the multi-professional teams striving to eliminate HAIs, it is our opinion that nurses are the driving force required to make a sustainable improvement in reducing the development of these preventable conditions. The growth of nurse-led collaboratives and quality improvement interventions in the PICU aimed at reducing the above problems are the first step in improving care for critically ill children and freeing them from additional and unnecessary critical care hospitalization (see Table 1 for sample nurse-led quality collaborative team).

Table 1. Sample nurse-led PICU quality collaborative team

Team member	Role
Nurse Manager	• Advisor to group • Oversee operations of collaborative • Perform follow-up with staff if needed from disciplinary perspective
Nurse Quality Leader	• Leads group • Sets meeting agendas • Follows up on issues related to quality • Performs data collection • Develops and presents reports to groups including pediatric intensive care unit and hospital quality collaborative • Monitors compliance • Participates in hospital-wide quality collaborative
Nurse members	• Perform data collection • Audit quality indicators for pediatric intensive care • Recommend system improvements • Implement process improvement

Introduction

It is critical to note that nurses are part of a multiprofessional team engaging in quality improvement to optimize health care outcomes. As such, the purpose of this review is to critically appraise the literature available from the past 3 years on nurse-driven quality and safety initiatives in the field of pediatric critical care. This review was focused on interventions related to decreasing HAIs. This remains a national patient safety goal and has significant consequence for individual institutions after being deemed non-reimbursable by the Centers for Medicare and Medicaid Services (CMS) in 2008 [1].

Recent findings

The impact of a quality improvement intervention to reduce hospital-acquired infections in a PICU

In a 2012 European Delphi study, reducing HAIs was one of the top pediatric critical care nursing research priorities [2]. As several organizations deem prevention of HAIs a priority, many institutions have deployed teams to target prevention. One hospital implemented a multifaceted improvement intervention consisting of the creation of an infection control team including physicians and nurses from infection control and the PICU [3]. Their work focused on an educational program highlighting hand hygiene and quality practice for maintaining invasive tubes and lines. The nursing members of the team were responsible for reminding colleagues about hand hygiene practice. One-hour workshops were conducted to focus on HAI prevention for patients with endotracheal tubes, central venous lines (CVLs), and urinary catheters.

As a result of these interventions, HAI rates improved from 32.8/1000 in the pre-intervention to 12.5/1000 patient-days in the intervention period ($p < 0.001$) [3].

Additionally, there was overall increased adherence to standardized practices, decreased hospital length of stay, and decreased mortality during and after the intervention period compared with the pre-intervention period [4]. This study also evaluated long-term standardized practice compliance and found it was stable. This is significant, as many studies have previously been able to prove decreased HAI rates with initial training, but there have been little data to document adherence to bundles after the initial intervention periods with sustained improvements [5•]. This study was the first to attempt reduction in HAIs using a multifaceted approach as well as evaluate long-term follow-up. This study demonstrates the need for an ongoing commitment to reduction of HAIs using refresher training sessions. To enhance long-term follow-up and commitment to a culture of reduction in HAIs, a variety of approaches may be useful to engage team members. Staff need to be given feedback on a monthly basis regarding HAI rates and identified problems, and the role of individual team members should evolve to maximize outcomes in order to foster expertise between the wide ranges of education necessary. HAI rates require ongoing evaluation as education is provided by designated team members. Formal education at routine intervals would reinforce behaviors and practices without causing information fatigue (see Table 2).

A quality improvement collaborative project to reduce pressure ulcers in PICUs

Critically ill children in the PICU can be immobile for prolonged periods of time. Immobility coupled with invasive tubes and lines requiring close adherence to the skin puts these children at increased risk for skin breakdown and PU formation. Stage III and stage IV PUs are serious reportable events [6]. This

Table 2. Approaches to engage team members in a quality culture

Activity	Pro	Con
Formal electronic communication	• Quick reminders via email • Can be sent to many members of the team at one time	• May be overlooked secondary to information overload
Instant messaging using mobile technology systems	• Quick reminders • Can reach many team members at once	• Limited information as space is limited for text messaging
Contests with small prizes via email, during lunch time, walking rounds, staff meetings, daily huddles	• Makes learning fun • Promotes team work • Engages all members of the team	• Requires time to create contest • Time for team member to run contest • Funding for small prizes
Individual recognition	• Enforces a job well done • Promotes team work	• Time sensitivity of recognition is critical • May be difficult to maintain with a large staff
Formal education (lecture, SBT, etc.)	• Comprehensive • Sharing complete process and outcome measurements • Multimodal approach for different leaner types	• Takes time to develop • Need to ensure time away from clinical care for participants
Refresher courses (after formal education is completed)	• Easy to perform • Requires limited time to perform	• May be difficult to coordinate with staffing and acuity level of patients

study aimed to decrease PU formation by 50% in the neonatal intensive care unit (NICU) and PICU after development of a collaborative leadership team and development of a quality improvement bundle. Key drivers such as evaluation of new PUs, skin assessments, and managing surfaces and moisture were created by the leadership team and implemented via rapid cycle small tests of change to initially refine the project before rolling out to the entire unit. Nursing staff was critical in the evaluation of the skin, and the intervention achieved a 50% reduction in development of PUs during the first year after implementation. Of PUs that were found, the majority were stage II and none were stage IV [6].

This is an important study as there is limited evidence available to demonstrate an intervention that has reduced the number of PUs in pediatrics. As expected, many of the PUs found during this study were associated with device placement in relation to lines and tubes. A reduction in PU rates was found during development of the intervention, which was attributed to increased awareness and more focused attention on the subject. Further research should be completed to study the specific issues surrounding PU development in patients requiring the use of non-invasive positive pressure facemasks, as this represented a significant proportion of patients who developed a PU. As this study did not discuss barrier device use for this group of patients, it is unclear if there would have been an improvement with use. Further study is needed in the area of barrier devices and PU formation in this population. Additionally, as many facemasks are not specifically designed to fit the pediatric population, a remodel may contribute to reducing the occurrence of mask-related ulcers.

Reducing catheter-associated urinary tract infections through quality initiatives

The greatest risk factor for acquiring a catheter-associated urinary tract infection (CAUTI) is the presence of a urinary drain. Davis and colleagues developed an institution wide standard of training, insertion, and maintenance practice for urinary drains. They also asked daily if the catheter was required and reviewed all CAUTIs [7]. After implementing this process, the mean monthly CAUTIs rate was reduced by 50% ($p = .02$), yet catheter utilization remained stable. This study clearly elucidates the importance of the application of a quality process to reduce HAIs.

Additional data on reduction of CAUTIs in the PICU is present in the international literature. Although this work has been done in developing countries, the use of quality initiatives again demonstrate a reduction in CAUTIs [8].

Simulation-based pediatric intensive care unit central venous line maintenance bundle training

Standardized insertion, care, and maintenance of CVLs are key components aimed at reducing CLABSIs, yet maintaining these skills can be challenging [5•]. A multi-professional team at a freestanding children's hospital developed simulation-based training (SBT) for CVL dressing change procedure in order to better comply with an already existing PICU CVL maintenance bundle. SBT has become a popular tool to encourage clinical competency and skill acquisition for adult learners in the health care setting [5•]. In this study, previously created didactic training on the maintenance bundle was used with post-testing evaluation after a competency assessment, and visual observation of a CVL dressing was completed. Nursing staff who functioned as investigators for the study

participated in direct observation of subjects' dressing changes and were then responsible for calculating CVL maintenance bundle scores. Follow-up training using SBT was provided for the purpose of refreshing nurses at three intervals after the initial training. The implementation of these measures provided a significant decrease in CLABSI rates; 1.9 ± 2.2 CLABSIs per 1000/CVL days for the 6 months pre-study to 0.6 ± 1.6 BSIs per 1000/CVL days for the last 6 months and immediately following the study (p = .034) [5•].

The approach used by the Hebbar and colleagues found a way to overcome common hurdles that exist in employing SBT, with timing and resources being two major factors [5•]. Completing the sessions at the nurses' bedsides proved to be efficient and impactful. The skill set was re-assessed for the intervention group at 3, 6, and 12 months intervals. This served as a means of assessing skill knowledge retention, previously documented as a challenge in adhering to maintenance bundles. Based upon the data documenting cost of treating a single CLABSI by Nowak et al. in 2010, the reduction in number of CLABSIs in this study was estimated at $500,000 in cost savings during the study period [5•]. In addition to reducing cost, interventions to reduce CLABSI rates can also impact decreasing hospital length of stay (HLOS) as prior work has demonstrated an additional 19 days of hospitalization due to a single CLABSI and increased mortality rates [4].

Effect of a real-time pediatric ICU safety bundle dashboard on quality improvement measures

There are many important quality and safety measures in the PICU. While many institutions are now adopting daily goal sheets or patient safety checklists as a means of standardizing care, these may miss the dynamic nature of care delivery in the PICU [9••]. One team developed a unit-wide real-time dashboard to reduce the amount of time needed to achieve patient-specific quality and safety compliance. A PICU care team was assembled consisting of physician and nurse leaders to classify the metrics that should be included. A set of six practices were identified; signed caregiver consent for treatment, daily order for restraints (if applicable), need for indwelling urinary catheter, presence of deep venous thrombosis (DVT) prophylaxis, evaluation for risk of PU development, and completed medication reconciliation at time of PICU admission. Each of the components was queried from the electronic health record. Any non-compliance was identified on a flat-screen dashboard via their bed space. The specific measure that was not achieved was individually displayed on a real-time basis (medical record queried every 5 min).

Of all the metrics studied, the initiation of a unit-wide dashboard was associated with a decrease in the number of urinary catheter days and improvement in completion of medication reconciliation. The other metrics were not affected. Reducing urinary catheter days alone may reduce CAUTIs in the PICU. CAUTIs contribute to a large number of HAIs, can lead to serious complications such as secondary bacteremia, and patient discomfort. It has been estimated that each year, more than 13,000 deaths are associated with UTIs [10]. The previously used patient daily goal sheets would only assess the need for a urinary catheter once per day, while the unit-wide dashboard was intended to serve as an ongoing constant reminder to all PICU staff.

Overall, the dashboard provided a simple ongoing reminder for common goals in the PICU that was easily viewable by all staff (see Table 3 for sample

Table 3. Sample quality initiatives

Patient safety and quality indicators	Peripheral intravenous line (PIV)	PIV timely assessments	R
		PIV extravasation rate (extravasations/1000 patient-days)	R HR U
		Verified extravasation measurement	R
		Extravasation management	R
		Days since last >60% extravasation	R HR
	Medication safety data	Number of medication events > D	R HR U
		Medication events ≥ D (YTD % error rate)	R HR U
		IVF/continuous medication labeling	R HR U
		High alert meds: RN co-sign	R HR U
	Specimen data	Mislabeled specimen (# of reports)	R HR U
		Unlabeled specimens (# of reports)	R HR U
	Skin health data	Skin assessment within 24 h of admission	R U
		Risk re-assessment every shift	R U
		Daily skin assessment	R U
		Device-related skin breakdown (n)	U
		Daily bath completed	U
Infection prevention and control	Respiratory HAIs	Hand hygiene	R HR
		Isolation compliance (observation entering)	R HR
		Isolation initiation (documentation)	R
		Family isolation education (documentation)	R
		PICU respiratory HAIs: viruses (n)	HR U
	CLABSI prevention	% CVC insertion bundle data completed	HR U

		No. of CLABSIs	HR U
		Central line bloodstream infection/1000 CVC days rate	R HR
		CL access bundle overall compliance	HR R
		CVC utilization rate	HR U
	CAUTI prevention	No. of CAUTIs	HR U
		Catheter associated infection/1000 catheter days rate	HR R U
		Urinary catheter bundle compliance	R
		Foley catheter utilization rate	HR U
Nursing quality indicators		Abuse: parents concern assessed	R
		Abuse: RN assessed for signs of abuse/neglect	R
		Suicide risk assessment	R
		Falls: risk assessment documented	R
		Falls: prevention education documented	R
		Interdisciplinary plan of care documented	R U
		ID bands: on patient, correct, and legible	HR R
		Documentation of re-assessment hourly until pain improved	HR R

R required, *HR* high risk, *U* unit specific, *n* number, *CL* central venous catheter, *CL* central line, *CLABSI* central line-associated blood stream infection, *CAUTI* catheter-associated urinary tract infection, *IVF* intravenous fluid

quality initiative dashboard). Care must be taken to protect personal health information especially when dashboards are located at a central nursing station. Consideration should be made to include additional patient safety measures in the future as well as other pertinent topics helpful for staff to visualize (i.e., active bed spaces, planned procedures, etc.).

Ventilator-associated pneumonia and nurse-led quality

Nurse-led quality initiatives to reduce pediatric VAP are sparse in the literature, although it is well known that nurses are critical to the implementation of quality initiatives. Richardson and colleagues describe a nurse-led VAP surveillance program, and the team comprised of a lead nurse, consultant intensivist and microbiologist, and an infection control nurse [11]. The team developed the VAP education program and educated the PICU staff. The identified VAP incidence was 5.6/1000 ventilator days using this process. They did not report on VAP incidence prior to the implementation [11].

The multi-professional team, led by Michael T. Bigham, implemented a VAP bundle and evaluated baseline VAP incidence and post implementation VAP incidence [12]. The implementation of each bundle element was led by respiratory therapists and nurses. PICU staff were educated using bundle checklists with reminders placed in patient rooms, real-time reporting to staff regarding incidence compliance, and number of infections. Staff who floated to the PICU received education during the orientation process on the VAP compliance bundle. The outcomes demonstrated a reduction in VAP incidence from 5.6 to 0.3 infections per 1000 ventilator days ($p < 0.0001$). They also demonstrated that children without VAP have statistically significant reductions in ventilator days (16.3± 14.7 days VAP vs 5.3 ± 8.4 days without VAP, $p < .001$), PICU length of stay (19.5 ± 15 VAP vs 7.5 ± 9.2 days without VAP, $p < .001$), and mortality (19.1% VAP vs 7.2% without VAP, $p = .01$) [12]. This early study clearly demonstrates the impact of a bundle on infection prevention.

Summary

There have been considerable advancements of nursing science contributions to pediatric critical care practice over the past two decades [2]. The literature discussed in this review includes a variety of interventions implemented to improve the care delivered to pediatric critical care patients as well as prevent adverse effects associated with their care. This is a common burden experienced in the PICU where many children require invasive lines and tubes and can be immobile for prolonged periods of time. Nursing interventions to reduce PUs, simulation training to improve compliance with maintenance bundle care for CVLs, and a multi-professional taskforce charged with the role of education in infection control for nurses and physicians are some ways nurses are driving quality. Nurses responsible for reminders regarding hand hygiene decreased HAI rates, HLOS, and mortality in the PICU. Attention to safety dashboards for real-time assessment of the need for invasive lines/tubes/restraints, ensure treatment consent was obtained, verify DVT prophylaxis, evaluate for PUs, and ensure medication reconciliation was completed has improved outcomes in pediatric critical care [9••]. Collectively, the included reviews constitute a significant contribution to pediatric critical care literature. The consistent theme amongst these studies is that involvement of PICU nurses in designing interventions to improve patient care and continuing to grant them responsibility in sustaining improvement is imperative to critically ill and injured children in all PICUs.

Conclusion

Nurses play a large part in the delivery of high-quality pediatric critical care and are major contributors to related outcomes. As bedside care providers, they may be responsible for identifying quality improvement opportunities. As PICU nurses continue to be given more autonomy at the bedside: sedation and vasopressor titration, evaluation of extubation readiness, etc., they continue to be key players in advancing patients' care 24-h per day and ensuring patients receive the highest level of care with minimal risk to complication. We believe this is appropriate, and nurses are educated and prepared to practice in this way.

The studies reviewed in this paper highlight some of the advances in decreasing HAIs, practice of skin assessments, and maintenance of invasive lines and tubes. Efforts to promote multi-professional collaboration and increase the inclusion of PICU nurses will not only increase support of PICU research and quality improvement efforts [13], but will continue to enhance the way patients are cared for with new interventions continuing to be developed for this vulnerable population.

Compliance with Ethical Standards

Conflict of Interest
Jacqueline Elegant declares that she has no conflict of interest. Lauren Sorce declares that she has no conflict of interest.

Human and Animal Rights and Informed Consent
This article does not contain any studies with human or animal subjects performed by any of the authors.

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- •• Of major importance

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