

Original Article

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Pressure injury prevention for paediatric cardiac surgical patients using a nurse-driven standardized clinical assessment and management plan

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Abstract

Background: The description of pressure injury development is limited in children with CHD. Children who develop pressure injuries experience pain and suffering and are at risk for additional morbidity. **Objectives:** The objective of this study was to develop a standardized clinical assessment and management plan to describe the development of pressure injury in paediatric cardiac surgical patients and evaluate prevention strategies. **Methods:** Using a novel quality improvement initiative, postoperative paediatric cardiac surgical patients were started on a nurse-driven pressure injury prevention standardized clinical assessment and management plan on admission. Data were recorded relevant to nursing assessments and management based on pre-defined targeted data statements and algorithm. Nursing feedback regarding diversions was recorded and analysed. **Results:** Data on 674 congenital paediatric cardiac surgical patients who met criteria were collected between May, 2011 and June, 2012. In 5918 patient days, a total of 4603 skin assessments were completed by nurses from the cardiac ICU and the cardiac inpatient unit, representing 77% of the expected assessments. The majority (70%, 21/30) of the 30 pressure injuries were medical-device-related and 30% (9/30) were immobility-related. The overall incidence of pressure injury was 4.4%: device-related was 3.1% and immobility-related was 1.3%. Most pressure injuries were Stage 1 (40%), followed by Stage 2 (26.7%), mucosal membrane injury (26.7%), and suspected deep tissue injuries (6.7%). **Conclusion:** A nurse-driven pressure injury prevention standardized clinical assessment and management plan supported a programme-based evaluation of nursing practice and patient outcomes. Review of practices highlighted opportunities to standardise and focus prevention practices and ensure communication of patient vulnerabilities.

There is growing evidence that children are at an increased risk of developing pressure injuries.^{1–3} The National Pressure Ulcer Advisory Panel, which serves as the expert voice in the United States of America regarding pressure injuries, recently updated the name from pressure ulcer to pressure injury, including adding an expanded definition of this phenomenon.⁴ Pressure injury is defined as

localized damage to the skin and/or underlying soft tissue usually over a bony prominence or related to a medical or other device. The injury can present as intact skin or an open ulcer and may be painful. The injury occurs as a result of intense and/or prolonged pressure or pressure in combination with shear. The tolerance of soft tissue for pressure and shear may also be affected by micro-climate, nutrition, perfusion, co-morbidities, and condition of the soft tissue.⁴

Pressure injury can lead to pain and suffering for patients and families, add additional morbidity, alter body image, increase the complexity of care, or potentially evolve into a life-threatening infection-related complication.^{5,6} The incidence of pressure injuries in children in paediatric ICUs has been reported from 0.8 to 27%.^{2,7} In a nationwide study of multiple paediatric ICUs, the aggregate rate of pressure injury by volume was 24.35 per 1000 patient days, ranging from 2.47 to 57.10 by site.² However, little is known about pressure injury development in hospitalised infants and children with CHD, resulting in little evidence to guide practice.

Background

CHD is the number one birth defect in the United States of America, affecting nearly 40,000 births annually.⁸ CHD is the leading cause of infant illness and death associated with birth defects.⁸ Many children today with CHDs are living longer into adulthood owing to ongoing medical, surgical, nursing, and technological advancements. One study using 2010 United States of America census data estimated that approximately one million children and approximately 1.4 million adults are living in the United States of America with CHD.⁹ Many children with CHD require life-long medical or surgical follow-up, and some require frequent or prolonged hospitalisations for diagnostic or interventional procedures, cardiac surgery, or other therapeutic management.

The adult population with CHD who continue to be cared for in paediatric hospitals is growing.¹⁰ Paediatric speciality procedure areas and inpatient units, including cardiac intensive care and cardiac inpatient units, are caring for an increasingly multi-age, complex cardiac population. In hospitalised adults, patients in ICUs, undergoing surgery, history of cardiac disease, spinal cord injury, or prolonged immobility, are at an increased risk of developing pressure injuries.^{11–14} Surgical patients have an increased risk of developing pressure injuries related to prolonged periods of immobility under anaesthesia and time in the operating room.¹⁵ Surgical procedures lasting more than four hours increase the risk of pressure-related tissue injury.^{13,16}

Adult patients requiring cardiac surgery present unique care challenges related to therapeutic interventions. During cardiac surgery, many patients undergo varying periods of cardiopulmonary bypass and hypothermia, which may affect tissue perfusion and oxygenation. Other common interventions in the operating room for cardiac surgical patients include general anaesthesia, administration of vasoactive medications, and the use of multiple medical devices for patient monitoring and therapeutic care that put the patient at risk for pressure injury development.¹⁷ For consistency, the new terminology of pressure injury will be utilised in this paper.

Little is known about paediatric cardiac surgical patients and the development of pressure injury. Paediatric cardiac surgical patients may be vulnerable to similar risk factors as adult cardiac surgical patients, including exposure to prolonged periods of immobility during complex surgical procedures.^{18,19} Prolonged periods of immobility may occur during other invasive diagnostic or interventional procedures such as cardiac catheterisation or in the ICU postoperatively.¹ In the cardiac ICU, some patients may need escalating medical interventions requiring advanced technology such as high-frequency oscillatory ventilation, extracorporeal membrane oxygenation, or ventricular assist devices, all limiting the patient's mobility. Moreover, paediatric cardiac surgical patients are exposed to multiple medical devices that are attached to, or cross over, the skin and are required for their care.

With the growing focus on quality care, patient safety, and reporting quality care metrics to regulatory agencies, there is a need to understand the development of hospital-acquired pressure injury and prevention strategies across patient populations. The Centers for Medicare and Medicaid Services defined the development of Stage 3 and Stage 4 pressure injuries as adverse patient safety events or “never events” that are reasonably preventable by implementing evidence-based prevention guidelines.²⁰ Some states mandate acute care hospitals, including paediatric hospitals, to report never events to the State

Department of Public Health within 7 days.²¹ Prevention of pressure injuries may lead to improved patient outcomes and potentially reduce resource utilisation by these complex patients and families that have been shown to use a disproportionately high share of hospital resources.^{22,23}

The problem

In the summer of 2009, despite ongoing pressure injury prevention strategies in the paediatric cardiac ICU, there was a spike in serious peri-sacral pressure injuries in postoperative patients, particularly in preteen to teenage patients. As a quality improvement initiative, an interdisciplinary Cardiovascular Pressure Ulcer Workgroup was re-established to review and refocus pressure injury prevention efforts. Strategies that utilise a comprehensive preventative approach can reduce the prevalence and incidence of pressure injuries.^{14,24}

Moreover, ongoing quality metric pressure injury surveillance data for the cardiac ICU in 2010 revealed 46 pressure injuries for cardiac surgical patients, with 70% (32/46) being medical-device-related and 30% (14/46) related to immobility. The overall pressure injury rate was 6.0/1000 patient days. The immobility-related rate was 1.8/1000 patient days, and the rate related to medical devices was 4.2/1000 patient days. Pressure injuries were staged using the National Pressure Ulcer Advisory Panel Staging Guidelines at the time.²⁵ When identified, pressure injuries were Stage 1 (26%), Stage 2 (30%), mucosal membrane injury (15%) related to medical devices, suspected deep tissue injury (15%), and unstageable (11%).

Relevant literature

Most pressure injury prevention interventions in paediatrics have been extrapolated from adult studies.²⁶ There is little available evidence about the development of pressure injury in children with CHD. Patients with CHD have been specifically excluded from study, as there was uncertainty about the effects of chronic hypoxaemia on the development of pressure injury.⁷ The impact of chronic hypoxaemia on the development of pressure injury in patients with CHD remains unclear today. Limited available evidence suggests that the incidence of pressure injury in children with CHD ranges from 16.9 to 25%.^{1,27}

An innovative approach

In response to the challenges of caring for patients with CHD, an innovative strategy for examining relevant clinical data to improve patient outcomes and reduce unnecessary resource utilisation within an improvement science framework was developed. Standard Clinical Assessment and Management Plans (SCAMPs™) are a novel quality improvement initiative conceived in the Cardiovascular Program, now known as the Heart Center, by the paediatric cardiologists and colleagues at a free-standing paediatric hospital in the northeast.²⁸ For the purposes of this manuscript, we will be referring to these types of assessment and management plans as SCAMPs™. The initial SCAMPs™ were physician-driven and outpatient focused.

Impressed by the initial outcomes of the cardiology SCAMPs™ and the concern regarding the lack of evidence about pressure injury development in patients with CHD, the cardiovascular nurses applied the SCAMP™ methodology. Our goal was to gain a better understanding of the development of pressure injury in hospitalised

infants and children with CHD and examine prevention strategies. Although all of the previous SCAMPs™ had been “treatment” focused, the pressure ulcer prevention SCAMP™ was the first with a “prevention” focus. The pressure ulcer prevention SCAMP™ is a standard pressure injury prevention plan to reduce practice variability among nurses initiated on patient admission. Owing to the lack of evidence in the literature and the Braden Q paediatric pressure ulcer risk assessment tool not validated in the paediatric cardiac population when this quality improvement initiative was undertaken, a preventative pressure injury approach was initiated upon patient entry to the Heart Center. The pressure ulcer prevention SCAMP™ was developed specifically for the prevention of pressure injury in postoperative cardiac surgical patients across the programme from the preoperative cardiology clinic through the inpatient cardiac units.

Strategy of the SCAMP™

The strategy of the pressure ulcer prevention SCAMP™ was to use existing knowledge about pressure injury development and prevention strategies to create a standard prevention plan to reduce practice variation across the Heart Center. According to Rathod et al’s process,²⁸ patients are assessed and managed in a standardised way using an algorithm to reflect sound practice. The SCAMP™ allows the clinical variability of the patient population to evolve, allowing for diversions from the standard plan to occur. These diversions are recorded to learn through analysis how the care of some patients may need to be modified in a safe and effective way.²⁸ Using the SCAMP™ approach, there was an opportunity to gain a better understanding of the decision-making process of the bedside nurse in providing pressure injury prevention care.

The SCAMP™ is re-evaluated at a predetermined point – for example, in 6–12 months – and may be changed based on a combination of best clinical judgement, evidence-based knowledge, and analysis of new data.²⁸ The SCAMP™ methodology offered an opportunity to better understand pressure injury development in paediatric cardiac surgical patients and to help build the foundational evidence for this vulnerable population.

Objective

The objective of this quality improvement project was to develop a standardized clinical assessment and management plan to describe the development of pressure injury in paediatric cardiac surgical patients and evaluate prevention strategies.

Materials and methods

SCAMP™ development

The pressure ulcer prevention SCAMP™ quality improvement effort was considered exempt by the organisation’s Institutional Review Board. In October 2010, an expert panel of 13 nurses was convened, including clinical nurse leaders, expert staff, and nurse scientists from across the Heart Center, to develop this important programme-wide collaborative initiative. This effort also received support from SCAMP™ managers, administrative staff, and biostatisticians. Using a consensus model, the expert panel developed key components of this first nursing SCAMP™ including a background paper¹⁸ to establish the state of the evidence about the paediatric cardiac population and the identification of 12 targeted data statements. Other forms developed as part of the process included an enrolment

form to identify inclusion and exclusion criteria, the pressure ulcer prevention SCAMP™ algorithm (©2010 Boston Children’s Hospital. All rights reserved), and the data collection form.

Targeted data statements, which were initially called plausible outcomes, are similar to hypotheses, which are explored by the SCAMP™ but do not require the same level of study in development as needed for a randomised clinical trial.²⁸ The targeted data statements, as described in Table 1, are a critical step in the development process as they help identify specific clinical statements to support evaluation of the SCAMP™.²⁸

The initial component of the SCAMP™ algorithm[®] used in the cardiac ICU and cardiac inpatient unit was the Standardized Pressure Ulcer Prevention Plan, as described in Table 2. This

Table 1. Targeted data statements.

1. The implementation of a preventative pressure injury SCAMP™ (or practice bundle) for patients will decrease the incidence and severity of pressure injury development	increased risk to develop subsequent pressure injury
2. The use of standard positioning and assessment guidelines will reduce the incidence of skin and/or device-related pressure injury in the patient	8. Patients with O ₂ saturations of <90% are at increased incidence for pressure injury
3. Applying standard skin care bundle for patients with a score of 1 or 2 for any Braden Q subscale will decrease pressure injury	9. The postoperative use of a low air loss mattress overlay for cardiac surgical patients > 20 kg with procedures > 4 hours will decrease the incidence of pressure injury
4. The use of a perioperative risk assessment tool will reduce the incidence of pressure injury occurring in the postoperative period	10. The standardised use of gel pads under the heads of patients ≤ 3 years of age on advanced technological support such as extracorporeal membrane oxygenation or high-frequency ventilation will prevent occipital pressure injury
5. The intraoperative use of a Dolphin Pad™ on patients over 15 kg will reduce the incidence of pressure injury in patients during surgical procedures	11. After implementation of the PUP SCAMP™ across the cardiovascular care continuum, there will not be a decrease in the risk-adjusted length of stay
6. A Braden Q score of 1 or 2 within any subscale will relate to pressure injury development for patients	12. After implementation of the PUP SCAMP™ across the cardiovascular care continuum, there will not be an increase in adverse events associated with pressure injury prevention strategies
7. Children with a history of one or more pressure injuries are at	

PUP = pressure ulcer prevention; SCAMP™ = Standard Clinical Assessment and Management Plans

Table 2. Cardiac ICU Standard Pressure Injury Prevention Plan.

* Head-to-toe skin assessment on admission ³² and every shift. ¹⁸ Pay attention to bony prominences, back, and under medical devices
* Braden Q risk assessment on admission ³² and daily ¹⁸
* Reposition the patient every 2 hours ³²
* Use pressure re-distribution surfaces and supports ³²
* Place heels off bed ³²
* Manage moisture ³²
* Optimise hydration and nutrition ³²
* Minimise device-related pressure: prop tubing off patient, prop device for proper alignment, and to prevent torque, avoid laying directly on devices, cords, tubing, and wires
* Place patient on low air loss mattress overlay directly from operating room if surgery or re-operation > 4 hours ¹⁸

Includes recommendations used and modified with permission from Ahern and Hickey¹⁸ and Institute for Healthcare Improvement³²

prevention plan was built on the limited evidence available and our previous prevention experience in the Heart Center including the Cardiovascular Program Pressure Injury Prevention Guidelines already in place.^{18,29} Pressure injury prevention interventions have been reported by organisations for adults.^{25,30,31} The Institute of Healthcare Improvement³² published a How-to-Guide supplement for paediatrics, including six essential elements for pressure injury prevention: on admission, perform both a skin and risk assessment; re-assess patient risk; daily skin assessment; manage moisture; optimise nutrition and hydration; and minimise pressure through repositioning and use of pressure re-distribution surfaces. Moreover, through our monthly review of our patient safety reports, we had seen a trend of pressure injury related to medical devices, so prevention strategies were included in the pressure ulcer prevention SCAMP™ to address specific medical devices. These interventions were bundled together and became the Standard Pressure Injury

Prevention Plan covering both immobility and medical-device-related pressure injuries.

SCAMP™ process

The pressure ulcer prevention SCAMP™ process started in the preoperative clinic to identify whether the patient had a previous history or existing pressure injury. A pre-procedure skin assessment was to be performed in the cardiac catheterisation lab or operating room to identify evidence of current skin injury. Perioperative pressure injury risk and intervention tools were developed and implemented in the cardiac operating room.¹⁹ A post-procedure skin reassessment was completed, and, if an area of skin concern was identified, this information was included during the handoff when the patient arrived to the inpatient units.

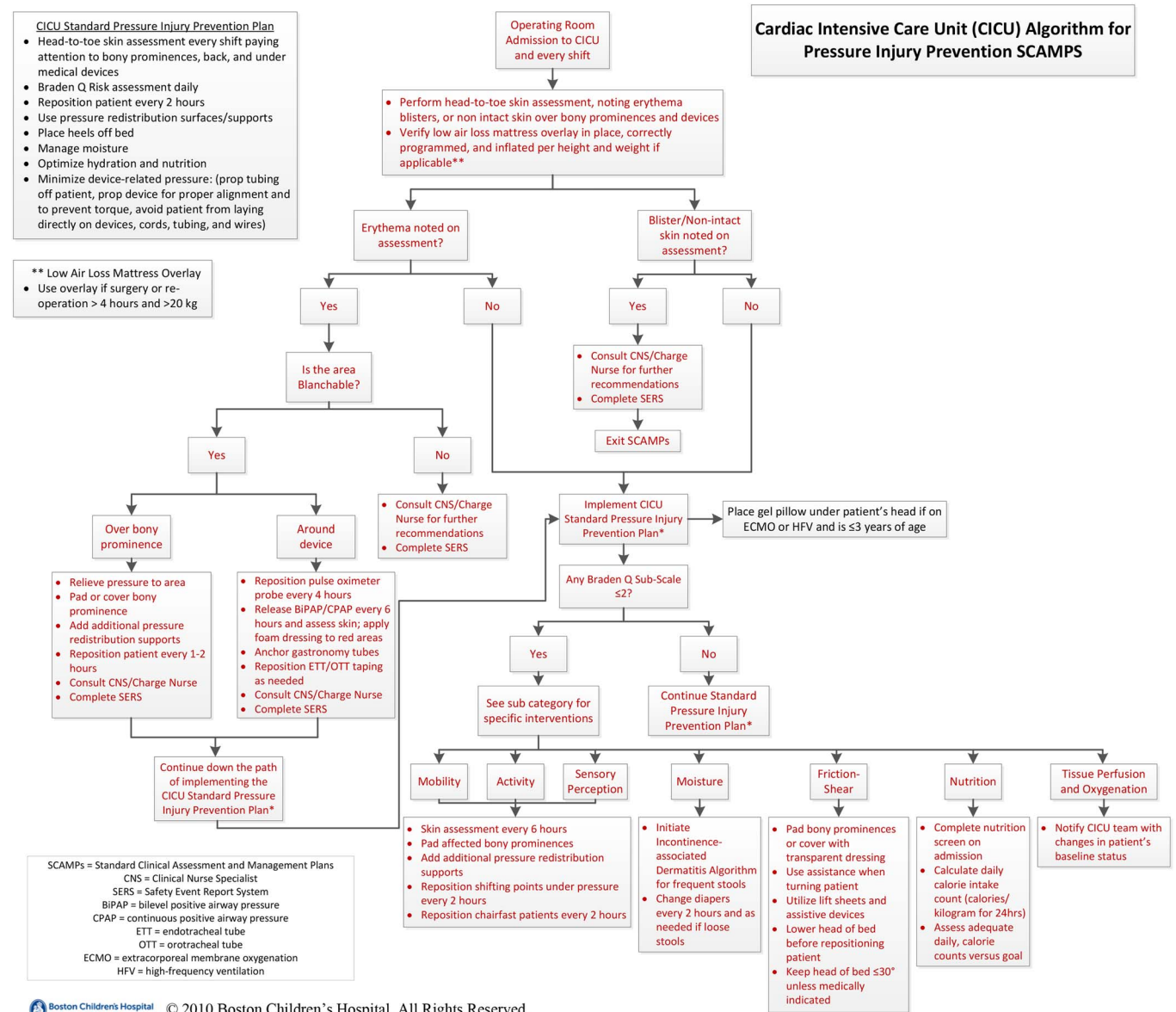


Figure 1. Inpatient pressure ulcer prevention SCAMP™ Algorithm®. A decision tree depicts the clinical management algorithm for patients admitted to the cardiac ICU based on clinical symptoms such as erythema, blistering, and non-intact skin. Separate boxes to the left of the decision tree summarise the key elements of the pressure ulcer prevention plan and appropriate mattress use.

The inpatient pressure ulcer prevention SCAMP™ algorithm® (see Fig 1) started with a head-to-toe skin assessment upon admission from the cardiac operating room to the cardiac ICU, and further skin assessments were performed and documented every shift by nurses. On the basis of these skin assessment findings, additional targeted interventions were recommended by the pressure ulcer prevention SCAMP™ in addition to the Standard Pressure Injury Prevention Plan. Skin assessments included looking at the patient’s skin for physical signs such as the presence of erythema or evidence of non-intact skin or blister, over a bony prominence or around a medical device.

As part of the pressure ulcer prevention SCAMP™, the patient’s risk for pressure injury development was assessed using the Braden Q Pressure Ulcer Risk Assessment Scale⁷ (see Fig 2) on admission and then daily. The Braden Q total score ranges from 7 to 28, with a score ≤16 identifying children “at risk” of developing pressure injuries. The SCAMP™ went beyond looking at the total score and included the strategy of looking at the seven subscales scored as 1 or 2 (higher risk) to respond to individual patient risk by implementing additional select interventions. If the

individual subscale scores were assessed at higher risk, targeted additional interventions were recommended according to the pressure ulcer prevention SCAMP™ algorithm® for each subscale in addition to the Standard Pressure Injury Prevention Plan.

Inclusion and exclusion criteria

Inclusion criteria for this quality improvement process were patients undergoing congenital cardiac surgery or cardiac transplantation, ages of 37 weeks up to 21 years old, and without pre-existing evidence of a pressure injury on preoperative assessment screening. Postoperative care must be provided in the cardiac ICU or the cardiac inpatient unit with an expected stay greater than 23 hours. **Exclusion criteria** included non-congenital cardiac surgery patients, cardiac medical patients, infants less than 37 weeks gestation, adults greater than 21 years old, and patients with a pre-existing pressure injury. Postoperative patients who met the inclusion criteria received the Standard Pressure Injury Prevention Plan with further preventative care assessed and managed according to the pressure ulcer prevention SCAMP™ algorithm®.

Intensity and Duration of Pressure					Score
Mobility The ability to change and control body position	1. Completely immobile: Does not make even slight changes in body or extremity position without assistance	2. Very limited: Makes occasional slight changes in body or extremity position but unable to completely turn self independently	3. Slightly limited: Makes frequent though slight changes in body or extremity position independently	4. No limitations: Makes major and frequent changes in position without assistance	
Activity The degree of physical activity	1. Bedfast: Confined to bed	2. Chair fast: Ability to walk severely limited or nonexistent. Cannot bear own weight and/or must be assisted in/to chair or wheelchair	3. Walks occasionally: Walks occasionally during the day, but for very short distances, with or without assistance. Spends majority of each shift in bed or chair	4. All patients too young to ambulate or walks frequently: Walks outside the room at least twice a day and inside room at least once every 2 hours during waking hours	
Sensory perception The ability to respond in a developmentally appropriate way to pressure-related discomfort	1. Completely limited: Unresponsive (does not moan, flinch, or grasp) to painful stimuli, due to diminished level of consciousness or sedation or limited ability to feel pain over most of body surface	2. Very limited: Responds only to painful stimuli. Cannot communicate discomfort except by moaning or restlessness or has sensory impairment which limits the ability to feel pain or discomfort over 1/2 of body	3. Slightly Limited: Responds to verbal commands, but cannot always communicate discomfort or need to be turned or has some sensory impairment which limits ability to feel pain or discomfort in 1 or 2 extremities	4. No impairment: Responds to verbal commands. Has no sensory deficit, which limits ability to feel or communicate pain or discomfort	
Tolerance of the Skin and Supporting Structure					
Moisture Degree to which skin is exposed to moisture	1. Constantly moist: Skin is kept moist almost constantly by perspiration, urine, drainage, etc. Dampness is detected every time patient is moved or turned	2. Very moist: Skin is often, but not always moist. Linen must be changed at least every 8 hours	3. Occasionally moist: Skin is occasionally moist, requiring linen change every 12 hours	4. Rarely moist: Skin is usually dry, routine diaper changes, linen only requires changing every 24 hours	
Friction and Shear <i>Friction:</i> occurs when skin moves against support surfaces <i>Shear:</i> occurs when skin and adjacent bony surface slide across one another	1. Significant problem: Spasticity, contracture, itching, or agitation leads to almost constant thrashing and friction	2. Problem: Requires moderate to maximum assistance in moving. Complete lifting without sliding against sheets is impossible. Frequently slides down in bed or chair, requiring frequent repositioning with maximum assistance	3. Potential problem: Moves feebly or requires minimum assistance. During a move, skin probably slides to some extent against sheets, chair, restraints, or other devices. Maintains relative good position in chair or bed most of the time but occasionally slides down	4. No apparent problem: Able to completely lift patient during a position change. Moves in bed and in chair independently and has sufficient muscle strength to lift up completely during move. Maintains good position in bed or chair at all times	
Nutrition Usual food intake pattern	1. Very poor: NPO and/or maintained on clear liquids, or IVs for more than 5 days or albumin <2.5 mg/dl or never eats a complete meal. Rarely eats more than ½ of any food offered. Protein intake includes only 2 servings of meat or dairy products per day. Takes fluids poorly. Does not make a liquid dietary supplement	2. Inadequate: Is on liquid diet or tube feedings/TPN which provide inadequate calories and minerals for age or albumin <3 mg/dl or rarely eats a complete meal and generally eats only about ½ of any food offered. Protein intake includes only 3 servings of meat or dairy products per day. Occasionally will take a dietary supplement	3. Adequate: Is on tube feedings or TPN, which provide adequate calories and minerals for age or eats over half of most meals. Eats a total of 4 servings of protein (meat, dairy products) each day. Occasionally will refuse a meal, but will usually take a supplement if offered	4. Excellent: Is on a normal diet providing adequate calories for age. For example: eats/drinks most of every meal/feeding. Never refuses a meal. Usually eats a total of 4 or more servings of meat and dairy products. Occasionally eats between meals. Does not require supplementation	
Tissue perfusion and oxygenation	1. Extremely compromised: Hypotensive (MAP <50mmHg; < 40 in a newborn) or the patient does not physiologically tolerate position changes	2. Compromised: Normotensive; oxygen saturation may <95% or hemoglobin may < 10 mg/dl or capillary refill may be >2 seconds; Serum pH is <7.40	3. Adequate: Normotensive; oxygen saturation may be >95% or hemoglobin may >10 mg/dl or capillary refill may be >2 seconds; Serum pH is normal	4. Excellent: Normotensive, oxygen saturation >95%, normal hemoglobin, and capillary refill <2 seconds	
Total:					

Reproduced with permission from Curley MAQ, Razmus IS, Roberts KE, Wypij D. Predicting pressure ulcer risk in pediatric patients: The Braden Q scale. 52(1) 22-33. <https://journals.lww.com/nursingresearchonline/pages/articleviewer.aspx?year=2003&issue=01000&article=00004&type=abstract>

Figure 2. Braden Q Scale. The Braden Q Scale is a paediatric risk assessment tool used to predict pressure injury in children. Each subscale is scored from 1 to 4, with a score of 1 (highest risk) to a score of 4 (lowest risk). The seven subscales are totalled with possible score ranges of 7–28. Patients with scores ≤16 are considered to be at risk of developing pressure injury.

Data collection

Data collection was initiated postoperatively on admission from the operating room by either the cardiac ICU or cardiac inpatient unit nurses. As the majority of cardiac surgical patients are directly admitted to the cardiac ICU, the majority of the data forms were initiated in the cardiac ICU. The data collection process was continued by the cardiac inpatient unit nurses when the patient transferred out of the cardiac ICU. Nurses self-reported data on admission and then daily on assessments and their decisions regarding the pressure ulcer prevention SCAMP™. As the recommended assessments and interventions was an all or none process to be considered on the pressure ulcer prevention SCAMP™, diversions from the pressure ulcer prevention SCAMP™ were expected. Diversions were recorded on the data form so that we could learn about care variability and nursing staff decision-making. The form included a short list of possible reasons for diversions, which included the following: patient/parent refusal, not medically able per doctors' orders, too busy during shift, objection to SCAMP™ recommendations, and other. The other option provided a space where nurses could write in their reasons. Patients continued on the pressure ulcer prevention SCAMP™ until hospital discharge, the patient was transferred out of the Heart Center, or a pressure injury developed.

Clinical Nurse Specialists with additional pressure injury education, including a Certified Wound Ostomy nurse or Certified Wound Ostomy Continence nurse in both the cardiac ICU and the cardiac inpatient unit, followed the National Pressure Ulcer Advisory Panel and European Pressure Ulcer Advisory Panel Clinical Practice Guideline²⁵ for staging if a pressure injury was identified. The pressure injury stages available at the time of this initiative included Stage 1 through Stage 4, unstageable, or suspected deep tissue injury. Pressure injuries found on mucous membranes related to medical devices were staged as mucosal pressure injury as per the National Pressure Ulcer Advisory Panel position statement.³³ Staff nurses were asked to notify the unit Clinical Nurse Specialists or certified wound nurses if they noted an area of erythema, blister, or concern of skin injury over a bony prominence or under a medical device to confirm whether a pressure injury developed. The unit-level wound experts staged the pressure injuries according to the staging guideline, using a consensus-based approach if there was any disagreement regarding staging.

The development and pilot of the cardiovascular nursing pressure ulcer prevention SCAMP™ occurred from October, 2010 to June, 2011. The pressure ulcer prevention SCAMP™ was rolled out across the Heart Center on 1 July, 2011, as described in Figure 3. Nursing education about the pressure ulcer prevention SCAMP™ was provided to nursing staff across the Heart Center before the rollout. After 6 months of implementation of the

pressure ulcer prevention SCAMP™, an interim analysis informed several modifications of the algorithm[®]. These changes included changing the frequency of position changes to every 2 hours and padding of "affected" bony prominences. The revised pressure ulcer prevention SCAMP™ began on 21 February, 2012. Data collection for analysis ended on 30 June, 2012.

Statistical methods

Descriptive statistics were used to summarise demographic and clinical characteristics, hospital encounters, and pressure injuries. In the case of non-normally distributed continuous data, median (minimum, maximum) was reported. The rates of pressure injury and corresponding 95% confidence intervals were estimated assuming a Poisson distribution. The associations between pressure injury development and potential risk factors were evaluated with t-tests and χ^2 tests or Fisher's exact test as appropriate. All analyses were performed using SAS v9.3 (SAS Institute Inc., Cary, North Carolina). Statistical significance was achieved with a two-sided p-value <0.05.

Results

Patient characteristics

A total of 674 children meeting inclusion criteria were available for review as described in Table 3. Among the 674 patients, there were some patients requiring more than one hospitalisation, resulting in 697 hospital encounters and 5918 patient days. Among the 674 patients, 117 were identified with oxygen saturations ≤ 90 and 557 with oxygen saturations >90 . The median combined length of stay in the cardiac ICU and cardiac inpatient unit was 7 days (range: 1–143). For patients in the cardiac ICU, the median length of stay was 4 days (range: 1–71). In the cardiac inpatient unit, the median was 3 days (range: 0–74). A total number of 4603 skin assessments were documented between the cardiac ICU and the cardiac inpatient unit nurses, representing 77% of the expected assessments. The total Braden Q pressure injury risk assessment score (mean \pm SD) for the cardiac ICU was 20.9 (± 3.6) and for the cardiac inpatient unit it was 25.3 (± 1.7).

Results per targeted data statements

Targeted data statement 1: *The implementation of a preventative pressure ulcer PUP SCAMP™ or practice bundle for patients will decrease the incidence and severity of pressure injury development.*

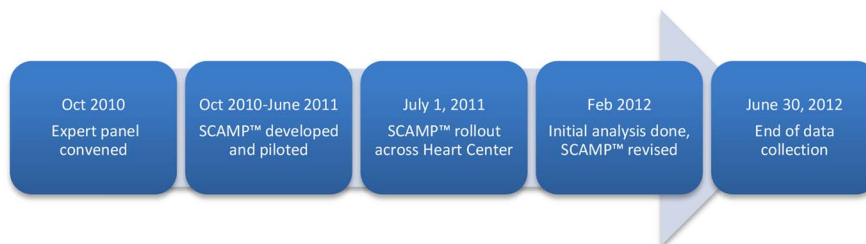


Figure 3. Timeline of pressure ulcer prevention Standard Clinical Assessment and Management Plans (PUP SCAMP™) development, rollout, and data collection. Blue blocks arranged chronologically from left to right denote the different phases and time frame for PUP SCAMP™ development, rollout, and data collection. Development started in October, 2010 and data collection ended in June, 2012.

Table 3. Admission and assessment summary.

	N
Patients	674
Admissions	697
Patient days	5918
Skin assessments recorded	4603
Length of stay (days)	Median (minimum, maximum)
Combined	7 (1, 143)
Cardiac ICU	4 (1, 71)
Cardiac inpatient unit	3 (0, 74)

Targeted data statement 2: *The use of standard positioning and assessment guidelines will reduce the incidence of skin and/or device-related pressure injury in the patient.*

Targeted data statement 3: *Applying standard skin care bundle for patients with a score of 1 or 2 for any Braden Q sub-scale will decrease pressure injury.*

In total, 29 patients developed 30 pressure injuries, as one patient developed a pressure injury in two separate admissions during the data collection period. The majority (70%, 21/30) of the pressure injuries were related to a medical device, whereas 30% (9/30) of the pressure injuries were immobility-related, as described in Table 4.

Before pressure ulcer prevention SCAMP™ implementation, the overall pressure injury rate was 6.0/1000 patient days. The immobility-related rate was 1.8/1000 patient days, and the rate related to medical devices was 4.2/1000 patient days. The overall pressure injury rate while using the pressure ulcer prevention SCAMP™ was 5.1/1000 patient days (95% confidence interval (CI): 3.5, 7.3). The rate for immobility-related pressure injury was 1.5/1000 patient days (95% CI: 0.8, 2.9), whereas the rate for medical-device-related injury was 3.5/1000 patient days (95% CI: 2.3, 5.4). The overall incidence of both immobility and device-related pressure injuries in this sample was 4.4%. The incidence of immobility-related pressure injury was 1.3%, and the incidence of medical-device-related pressure injuries was 3.1%.

Overall, 12 (40%) pressure injuries were Stage I and eight (26.7%) were Stage 2 when identified. Two pressure injuries (6.7%) were staged as suspected deep tissue injuries, and eight (26.7%) were staged as mucosal membrane injury as they were on mucous membranes and medical-device-related. These findings of reduced pressure injury severity as compared with previous surveillance data suggest support for targeted data statement 1.

Of the nine pressure injuries that were immobility-related, almost half (44.4%, 4/9) were located on the occiput, 22.2% (2/9) on the back/spine, 22.2% (2/9) on the buttocks, and 11.1% (1/9) on the coccyx. Most (62%) of the medical devices associated with pressure injury were oral endotracheal tubes (9/21) and nasal endotracheal tubes (4/21). Other medical devices associated with pressure injury were peripheral vascular access hubs (3/21), oxygen saturation probes (2/21), foley hub (1/21), nasogastric tube (1/21), and continuous positive airway pressure facial mask (1/21).

Table 4. Pressure injury characteristics and Braden Q Scoring (total pressure injuries N = 30).

	n (%)
Location of injury	
Bony prominence	9 (30.0)
Device	21 (70.0)
Injury stage*	
Stage 1	12 (40)
Stage 2	8 (26.7)
Suspected deep tissue injury	2 (6.7)
Mucosal	8 (26.7)
Developed PI with any Braden Q Subscale ≤ 2	23 (76.7)
Braden Q Subscale ≤ 2 with injury	
Mobility	14 (60.9)
Nutrition	14 (60.9)
Sensory perception	13 (56.5)
Activity	12 (52.2)
Tissue perfusion and oxygenation	6 (26.1)
Moisture	1 (4.3)
Friction shear	1 (4.3)
Injury rate* (per 1000 patient days)	Rate (95% CI)
Overall	5.1 (3.5, 7.3)
Bony prominence	1.5 (0.8, 2.9)
Device	3.5 (2.3, 5.4)

CI = confidence interval; PI = pressure injury

Any subscale ≤ 2 category is multi-selection

*Rounding may affect totals

Overall, 80% of the pressure injuries occurred within 7 days of the cardiac surgery, with 90% of the pressure injuries identified in the cardiac ICU.

Targeted data statement 4: *The use of a perioperative risk assessment tool will reduce the incidence of pressure injury occurring in the postoperative period.*

Patients (N = 673) were assessed for pressure injury risk using a Perioperative Risk Assessment Scale. The majority (77.9%, 524/673) of the patients were assessed as at risk for pressure injury, with 4.4% (n = 23) patients actually developing a pressure injury post-operatively. Some patients (22.1%, 149/673) were assessed as not at risk using the Perioperative Risk Scale, but 4% of these patients (n = 6) did develop pressure injury during the postoperative period. The use of this tool was not found to be statistically significant (see Table 5) and did not support targeted data statement 4.

Targeted data statement 5: *The intraoperative use of a Dolphin Pad™ on patients over 15 kg will reduce the incidence of pressure injury in patients during surgical procedures.*

Table 5. Association between patient factors and pressure injury development.

	Patients (N)	Developed pressure injury (N (%))	p Value
Age at SCAMP™ entry (years, mean ± SD)	644 4.1 (±5.4)	29 3.8 (±5.3)	0.77
Braden Q Scoring			
Any subscale ≤ 2	448	27 (6.0)	0.005
All subscales > 2	226	3 (1.3)	
O ₂ saturation			
Any O ₂ saturation < 90%	117	15 (12.8)	< 0.0001
All O ₂ saturation ≥ 90%	557	15 (2.7)	
History of previous pressure injury			
Yes	5	1 (20.0)	0.20
No	668	28 (4.2)	
At risk based on OR risk assessment			
Yes	524	23 (4.4)	0.85
No	149	6 (4.0)	

Includes only patients (hospital admission level) with Any Braden Q Subscale ≤ 2 = Yes/No

If a patient ever had Any Braden Q Subscale ≤ 2 then the patient is in the Yes group

One patient with pressure injury was excluded because the patient had no Braden Q score information

One patient developed pressure injury in two separate hospital admissions. Both times had Braden Q score ≤ 2 and developed pressure injury

Include only patients (hospital admission level) with O₂ saturation < 90 = Yes/No

One patient with pressure injury was excluded because the patient had no O₂ saturation information

Inasmuch the Dolphin Pad™ (Biologics Inc., Clearwater, Florida, United States of America) is a key component of the cardiac operating room pressure injury prevention plan, this quality improvement initiative could not determine the individual impact of this intervention and provide specific data regarding targeted data statement 5.

Targeted data statement 6: *A Braden Q score of 1 or 2 within any subscale will relate to pressure injury development for patients.*

In all, 6% (27/448) of paediatric cardiac surgical patients who had at least one Braden Q subscale scored 1 or 2 developed a pressure injury compared with 1.3% (3/226) of patients with all subscales > 2. This difference was statistically significant ($p = 0.005$) and suggests support for this targeted data statement requiring further study. The Braden Q subscales that were more frequently scored as 1 or 2 in patients who developed pressure injuries were mobility, activity, sensory perception, and nutrition.

Targeted data statement 7: *Children with a history of one or more pressure injuries are at increased risk to develop subsequent pressure injury.*

Five patients had a previous history of pressure injuries, but only one patient (20%) with a previous history developed a pressure injury in this sample. This was not significantly different from the rate in patients without a history of pressure injury (4.2%, $p = 0.20$). These findings did not support this targeted data statement, but the number of children with a history of pressure injury was small and warrants further study.

Targeted data statement 8: *Patients with oxygen saturations of < 90% are at increased incidence of pressure injuries.*

Patients with oxygen (O₂) saturations of < 90% ($n = 117$) were more likely to develop a pressure injury ($p < 0.0001$) in this

initiative. These findings are in support of this targeted data statement and warrant further study.

Targeted data statement 9: *The postoperative use of a low air loss mattress overlay for cardiac surgical patients > 20 kg with procedures > 4 hours will decrease the incidence of pressure injury.*

In total, 23 patients were on the standard hospital pressure redistribution mattress and did not use the low air loss mattress overlay and none had pressure injury identified. Of the 45 patients who were on the low air loss mattress overlay, only one (2.2%) developed a pressure injury. There is not enough data to evaluate this targeted data statement.

Targeted data statement 10: *The standardized use of gel pads under the heads of patients ≤ 3 years of age on advanced technological support such as extracorporeal membrane oxygenation or high-frequency ventilation will prevent occipital pressure injury.*

In total, 10 patients on extracorporeal membrane oxygenation were started on the pressure ulcer prevention SCAMP™. Of these 10 patients, most (9/10) were reported to have gel pads placed under the head, with 22.2% (2/9) developing an occipital pressure injury. There is not enough data to evaluate this targeted data statement.

Targeted data statement 11: *After implementation of the PUP SCAMP™ across the cardiovascular care continuum there will not be a decrease in the risk adjusted length of stay.*

The bedside data collection did not support answering this targeted data statement regarding the implementation of the pressure ulcer prevention SCAMP™ and the risk-adjusted length of stay. Further study and analysis would be needed to address this targeted data statement.

Targeted data statement 12: *After implementation of the pressure ulcer prevention SCAMP™ across the cardiovascular care continuum there will not be an increase in adverse events associated with pressure injury prevention strategies.*

There was no baseline data for comparison with the pressure ulcer prevention SCAMP™ data to address this targeted data statement.

Diversions from pressure ulcer prevention SCAMP™

Skin assessments

In the cardiac ICU, the nurses self-reported performing a complete skin assessment 86.6% of the time. In the cardiac inpatient unit, the nurses self-reported completing skin assessments 81% of the time. A complete skin assessment included assessing the patient from head-to-toe, including both the anterior and posterior aspects. The most common reasons cited by nurses for not performing a complete skin assessment were patient-related factors of “patient too unstable” and “patient on extracorporeal membrane oxygenation”.

Prevention strategies

The frequency of nursing diversions from the pressure ulcer prevention SCAMP™ recommendations varied between the cardiac ICU and the cardiac inpatient unit nurses. In the cardiac ICU, the nurses reported diverting from the pressure ulcer prevention SCAMP™ 43% of the time. Over half (57.3%) of the diversions occurred when targeted interventions were recommended in addition to the Standard Pressure Injury Prevention Plan for any Braden Q subscale that was scored 1 or 2 and considered subscales at higher risk. The cardiac inpatient unit reported 20 diversions from the pressure ulcer prevention SCAMP™, which was less than 1% of the time. The cardiac inpatient unit nurses primarily reported following the Standard Pressure Injury Prevention Plan.

Nurses were asked to document the diversions from the pressure ulcer prevention SCAMP™. In both the cardiac ICU and the cardiac inpatient unit, the primary diversion documented were the nurses' objection to the SCAMP™ recommendations. As shown in Table 6, the most frequent objections documented were owing to the patient not being turned hourly ($n = 774$) or a lack of pads over a bony prominence ($n = 730$). These recommendations were part of the additional targeted interventions if patients had a Braden Q immobility subscale score of 1 or 2, reflecting higher risk. The most common recorded diversion if the nutrition subscale was scored at higher risk was not performing daily calorie counts ($n = 121$).

The next largest diversion was noted as “Other” where the nurses were able to write in a specific reason for the diversion. As the nurses were encouraged to write in their diversions, data were collated as documented and then organised by themes. Many reasons for the diversions recorded by the nurses under “Other” were patient-related. The most common patient-related reasons were the patient was a fresh postoperative/fresh operating room case, the patient was on extracorporeal membrane oxygenation, and the patient was too unstable.

Discussion

The SCAMP™ methodology is an innovative quality improvement approach used where evidence is limited to guide care and decision-making for varying patient populations.²⁸ Application of

Table 6. Diversions from pressure ulcer prevention Standard Clinical Assessment and Management Plans recommendations.

	n
Diversions from pressure ulcer prevention Standard Clinical Assessment and Management Plans recommendations	
Diversions from pressure ulcer prevention Standard Clinical Assessment and Management Plans recommendations	
Diversions from pressure ulcer prevention Standard Clinical Assessment and Management Plans recommendations	
Patient not turned hourly	774
No pad under bony prominence	730
No calorie count	244
Did not turn patient every 2 hours	62
No admission nutrition screening	11
Frequency of diaper change	3
Diversions from pressure ulcer prevention Standard Clinical Assessment and Management Plans recommendations	
Diversions from pressure ulcer prevention Standard Clinical Assessment and Management Plans recommendations	
Diversions from pressure ulcer prevention Standard Clinical Assessment and Management Plans recommendations	
Fresh postoperative/fresh operating room case	157
Not necessary	93
Patient on extracorporeal membrane oxygenation	40
Too unstable	37
Patient agitation/sedation issues	9
Procedure-related	7
Patient asleep	6
Patient repositions self	5
Nurse busy	3
Other, not specified	14

the pressure ulcer prevention SCAMP™ is a nurse-driven approach to prevent pressure injury among paediatric congenital cardiac surgical patients across the Heart Center care continuum. To the authors' knowledge, this is the largest sample ($N = 674$) of paediatric congenital cardiac surgical patients to describe pressure injury development and prevention strategies for this vulnerable population where evidence is limited.

A total of 29 patients developed 30 pressure injuries. The majority (70%) of the pressure injuries were related to the use of a medical device, with 30% related to immobility. The overall incidence of pressure injury in paediatric cardiac surgical patients in this quality improvement initiative was 4.4%. The incidence of medical-device-related pressure injury was 3.1% and 1.3% for immobility-related pressure injuries. These data represent a decrease from the pre-pressure ulcer prevention SCAMP™ 2010 cardiac ICU incidence of 6%. The overall pressure injury rate by volume while using the pressure ulcer prevention SCAMP™ was 5.1/1000 patient days. The rate for immobility-related pressure injury was 1.5/1000 patient days, whereas the rate for medical-device-related injury was 3.5/1000 patient days. These data represent a decrease in the overall pressure injury rate before pressure ulcer prevention SCAMP™ of 6.0 to 5.1 per 1000 patient days. Immobility-related pressure injury decreased from 1.8 to 1.5 per 1000 patient days, and device-related injury decreased from 4.2 to 3.5 per 1000 patient days. These findings are consistent with other authors describing successful prevention strategies in decreasing the incidence of pressure injury in paediatric critical care patients.^{1,3,24}

The majority (70%) of the hospital-acquired pressure injuries found in this initiative were medical-device-related. The pressure ulcer prevention SCAMP™ data were consistent with previous cardiac ICU surveillance, in that the majority of pressure injuries in the cardiac ICU were related to the use of medical devices. This finding was consistent with other authors who have reported that hospitalised infants and children are at risk for iatrogenic injury related to medical devices used for therapeutic interventions.^{24,34} Medical-device-related pressure injury was found primarily on mucous membranes related to airway devices. Updated pressure injury definitions include both medical-device-related pressure injury resulting from devices designed and used for diagnostic or therapeutic indications and mucosal membrane pressure injury located on a mucous membrane where previously a medical device was in place.⁴

On the basis of the pressure ulcer prevention SCAMP™ findings, nursing education and prevention efforts were revised to include skin care prevention strategies such as recommended skin assessments and need for padding under certain medical devices. As a result of this initiative, the cardiovascular nursing pressure injury prevention guidelines were modified to include the prevention strategies for medical device usage.

The severity of most of the pressure injuries identified during the SCAMP™ process was considered minor and staged as Stage 1 (40%) or Stage 2 (26.7%). Two (6.9%) potentially more serious injuries, staged as suspected deep tissue injury, were identified and additional prevention strategies and treatment were initiated to minimise further skin injury. Using the pressure ulcer prevention SCAMP™ strategy, the severity of the identified pressure injuries decreased as compared with the pre-pressure ulcer prevention SCAMP™ surveillance.

The most frequent diversion from the initial version of the pressure ulcer prevention SCAMP™ by the bedside nurse was not turning the patient hourly and lack of padding of bony prominences. Hourly position changes for patients may have been too idealistic as an intervention for many nurses to support even if the patient was scored at higher risk. On the initial version of the pressure ulcer prevention SCAMP™, a generalised statement to pad bony prominences was also used and again could not be supported by the nursing staff, as bony prominences in a child with CHD is commonly seen. The pressure ulcer prevention SCAMP™ was modified after 6 months of implementation from repositioning of patients every hour to every 2 hours and pad bony prominences with evidence of erythema or concern. Both changes increased adherence to the pressure ulcer prevention SCAMP.

Another frequent nursing diversion was a lack of a documented patient calorie count. If the patient scored at higher risk on the nutrition subscale, the pressure ulcer prevention SCAMP™ recommended a calculation of the patient's caloric intake. This diversion reinforced the need to identify the barriers related to achieving daily calorie count calculations and identify potential resources for the nursing staff.

Many nurses recorded diversions regarding skin assessments or turning the patient. Both related to their concerns of the patient's early postoperative status, patient instability, or the patient was on extracorporeal membrane oxygenation. These recorded diversions were important to capture the clinical judgement and decisions of the bedside nurses to limit repositioning of patients related to perceived concerns regarding patient safety or instability. Some nurses' clinical decisions may have included that the patient may not tolerate the position change or skin assessment and become haemodynamically unstable. These

concerns related to patient instability and the use of some pressure injury interventions are consistent with reports by others.¹¹ These nursing concerns help support the need to develop strategies for nurses to be able to readily access pressure injury prevention resources including appropriate pressure re-distribution mattresses and overlays, other pressure re-distribution support aides or surfaces, and materials such as dressings for padding bony prominences, especially for patients with limited mobility and haemodynamic instability.

On the basis of the targeted data statements, two statistically significant risk factors for the development of pressure injuries in this group of patients were any oxygen saturation less than 90%; and any Braden Q subscale scored as 1 or 2. Both of these factors need further study to help understand whether these are potential risk factors associated with pressure injury development in patients with CHD.

Limitations

A limitation of this quality improvement initiative was that the data relied on self-report from the bedside nurses, a potential for bias related to under-reporting. These data were recorded on paper, adding an additional data burden to an already busy workload for the cardiac nurses, leading to missing data. Not all patients who met inclusion criteria were included or forms were not returned, as 77% of the expected forms were returned for review and analysis. Owing to the data burden, not all of the proposed targeted data statements could be addressed in this initiative requiring further study. Another potential limitation is that an "all or none" approach was used to evaluate whether nursing staff followed the pressure ulcer prevention SCAMP™. This approach probably decreased the calculated nursing compliance rate but helped us learn from the diversions recorded by the nurses. In addition, there may have been a halo effect during the SCAMP™ implementation and data collection period, where nursing staff were aware that data were being collected about compliance, which may have affected their actions.

Next steps/future implications

Using the data from this quality improvement initiative, we have modified the current Heart Center Pressure Injury Prevention Guidelines to include the Standard Pressure Injury Prevention Plan implemented for all patients admitted to the cardiac ICU. This Heart Center Pressure Injury Prevention Guideline is linked to other hospital guidelines so that the nurses can link to other documents to select interventions to manage individual patient risk. Assessments and interventions aimed at preventing medical-device-related pressure injury have been expanded in our updated guidelines. Documentation in the electronic medical record of prevention interventions utilised for patient care has been emphasised to staff. Ongoing vigilance and surveillance of pressure injury outcomes are needed with the sharing of findings with staff important to promote positive patient outcomes and high-quality care.

Conclusions

A nurse-driven pressure injury prevention SCAMP™ supported successful evaluation of nursing practice and patient outcomes across the care continuum where evidence in the literature is limited. This programme-wide approach, along with ongoing surveillance of patient outcomes, was an important strategy to

decrease the incidence and severity of pressure injuries in post-operative paediatric cardiac surgical patients. This quality improvement process yielded important data in both pressure injury development in this vulnerable population and nursing feedback regarding pressure injury prevention strategies. Identification and analysis of diversions were key, providing valuable insights regarding bedside nurses' challenges or barriers in following a Standardized Pressure Injury Prevention Plan and additional targeted interventions, particularly in the cardiac ICU. Review of nursing practices highlighted opportunities to standardise and focus pressure injury prevention interventions as well as ensure communication of patient vulnerabilities. As a result, the Heart Center Pressure Injury Prevention Guidelines were modified, incorporating staff feedback. Continuing vigilance and surveillance of pressure injury outcomes are needed in this vulnerable paediatric population.

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Conflicts of Interest. None.

Ethical Standards. The pressure ulcer prevention SCAMP was considered exempt by the organisation's Institutional Review Board as it was deemed quality improvement.

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