Evaluation of an Evidence-Based Care Bundle for Preventing Hospital-Acquired Pressure Injuries in High-Risk Surgical Patients

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ABSTRACT

The aim of this study was to evaluate the effectiveness of an evidence-based care bundle to prevent perioperative pressure injuries. In a single facility, using a preintervention and postintervention quasi-experimental design, we compared the pressure injury incidence rate for two patient groups (ie, before and after care bundle implementation). The bundle included a variety of elements, such as educating patients, applying protection, controlling skin moisture, and using pressure-relieving devices according to the patient's risk. Before the intervention, patients received standard care before procedures that did not address risk for pressure injury development. The study involved a total of 944 patients, and the incidence of pressure injury was lower in the postintervention group than in the preintervention group (1.6% versus 4.8%; $P < .001$). However, the odds ratio was nonsignificant and therefore the clinical relevance of the bundle is unclear. Additional research with a control group and multiple sites is needed.

Key words: *hospital-acquired pressure injury (HAPI), care bundle, risk assessment, alternating air mattress, silicone foam dressing.*

A *hospital-acquired pressure injury* (HAPI) involves "[l]ocalized damage to the skin or underlying tissue caused by pressure or pressure in combination with shear"[1(p770)] that occurs during an inpatient hospital stay.[2] Blanchable erythema or changes in sensation, temperature, or firmness may precede visible skin changes.[3] The appearance of skin erythema varies according to the amount of pigment present.[4] Purple or maroon discoloration may indicate a deep tissue pressure injury.[4] A variety of factors (eg, patient position, type of anesthesia, length of surgery, patient comorbidities) can contribute to the development of perioperative HAPIs.[5]

Despite technological advancements and the availability of pressure-relieving devices, pressure injuries continue to occur. A 2016 systematic literature review with meta-analysis showed that the estimated prevalence of postoperative HAPIs in unspecified countries was 18.96% (95% confidence interval [CI] = 15.3 to 22.6).[6] In 2020, the global pooled estimate of pressure injury prevalence in hospitalized adult patients was 12.8% (95% CI = 11.8 to 13.9) and the incidence rate was 5.4 per 10,000 patient days; further, the rate of HAPIs was 8.5% (95% CI = 7.6 to 9.3).[7] Results of a 2021 point prevalence study in 90 countries showed that the overall prevalence of HAPIs in intensive care units (ICUs) was 26.6% (95% CI = 25.9 to 27.3).[8]

Treating preventable HAPIs can be costly and time-consuming. Results of a systematic review of articles published between 2001 and 2013 in the United States,

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Canada, the Netherlands, and the United Kingdom on pressure injuries occurring in hospitals and nursing homes showed that the cost of treating such injuries for a patient ranged from €1.71 to €470.49 ($1.86 to $512.83) per day and the cost of preventing them ranged from €2.65 to €87.57 ($2.89 to $95.45) per day.[9] In the United States in 2016, the average cost of care for a patient with any type of HAPI was $10,708; and the total incidence of reported HAPIs was 2.5 million cases, resulting in an annual cost of more than $26.8 billion.[10] Therefore, early identification of pressure injury risks and prevention methods is imperative for cost-effective and high-quality care.

Perioperative patient care is complex and involves interdisciplinary team collaboration. Postoperative pressure injuries may not be visible immediately and can take from 18 to 72 hours to develop,[11] making it difficult to identify the stage of the perioperative continuum (ie, preadmission, preoperative, intraoperative, postoperative) in which gaps in care may have occurred. A collaborative and systematic approach at every stage of care is needed to prevent HAPIs among surgical patients, and perioperative nurses should participate in pressure injury prevention initiatives.[1] Findings from a systematic review on nurses' attitudes associated with pressure injury prevention suggest that, overall, nurses report a positive attitude toward pressure injury prevention but experience barriers to implementing prevention strategies.[12]

BACKGROUND

Singapore General Hospital, an academic medical center, is one of the oldest and largest acute care hospitals in Singapore. Surgeons perform more than 92,000 inpatient and elective procedures annually[13] across a variety of disciplines, including oncology, general surgery, orthopedics, and urology.[14]

Internal audit data (December 2017) showed that the HAPI incidence rate was 4.75%. To achieve zero harm, we developed, implemented, and evaluated the effectiveness of a perioperative HAPI prevention care bundle. Before this study, nurses used the standard pressure injury prevention practices after procedures for patients at risk of developing a pressure injury. They involved regular repositioning of the patient (ie, every two hours), performing skin care (eg, application of skin barrier cream at the end of perineal care), and using pressure-relieving or pressure-redistributing devices (eg, alternating air mattress, overlay). Postoperative use of alternating air mattresses was based on the patient's risk factors.

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REVIEW OF THE LITERATURE

Researchers used a before-and-after study design to evaluate perioperative nurses' knowledge of HAPI risks, risk assessment, and prevention strategies and their reported practices associated with assessment and prevention.[15] A multifaceted educational intervention comprised a 30-minute presentation, reference material, and reminder posters that incorporated national guidelines for pressure injury and published research. Risk assessment tool use increased from 12% before the intervention to 40% after the intervention, and chi-square analysis (χ^2) showed significance ($\chi^2_1 = 3.26$, $P = .0001$). Clinical judgment involving device use increased from 9% before the intervention to 27% after the intervention ($\chi^2_1 = 01$, $P = .008$).[15] However, the number of nurses using devices that were not recommended (ie, evidence indicated they should not be used) or devices with no evidence at all were the same before and after the intervention, and the overall use of recommended devices remained the same throughout the study.

The researchers noted that it was difficult to shift practice based on the evidence, even when the perioperative nurses had sufficient knowledge regarding pressure-relieving devices.[15] They also noted that the preferences of other perioperative team members (eg, surgeon, anesthesia professional) may influence the nurses' ability to implement evidence-based practice changes.

A *care process model*[16,17] or *bundle*[18] is a collection of evidence-based interventions used to standardize and promote best clinical practices.[16,17] By enhancing consistency and reducing practice variations, bundles can assist nurses in providing the most appropriate, evidence-based, and cost-effective patient care.[18]

Several care bundles have been developed to enhance care delivery in acute[19] and long-term care[20] facilities and to address a variety of patient care concerns (eg, pressure

injury prevention,[20] musculoskeletal infections,[21] surgical site infection prevention[22]). The bundled interventions resulted in increased compliance with pressure injury prevention initiatives,[19] increased days between pressure injury events,[19] and decreased time from diagnosis of a musculoskeletal infection to antibiotic administration.[21] However, the findings associated with surgical site infection bundles showed mixed results.[22]

The SSKIN (skin, surface, keep moving, incontinence, nutrition and hydration) bundle is designed to be used in all areas of health care in which patients are at risk for development of pressure injuries.[23] The SSKIN care bundle involves the following key elements:

- skin assessment and inspection to detect redness, administration of timely treatment, management of moisture, and prevention of dryness;
- assessment of the positioning surface and selection of the most appropriate pressure-reducing or pressure-relieving devices;
- keep moving with frequent repositioning and activity;
- incontinence management involving silicone barrier creams rather than those with oils or heavy metals; and
- nutrition status and hydration level assessment.[23]

We adopted principles from the SSKIN bundle when developing our pressure injury prevention care bundle.

Perioperative HAPI Prediction Tool

The surgical pressure ulcer risk score (SPURS) is a validated prediction tool with high sensitivity and specificity that nurses can use preoperatively to identify a patient's risk for pressure injury development.[14] The tool comprises identified risk factors, including

- 75 years of age or older;
- female gender;
- American Society of Anesthesiologists (ASA) Physical Status Classification[24] score of at least III;
- body mass index less than 23 kg/m^2;
- preoperative Braden Scale for Predicting Pressure Sore Risk (eg, a general pressure injury risk tool[25]) score of 14 or less; and
- comorbidities of anemia, respiratory disease, and hypertension.[14]

The SPURS tool has good discrimination ability with a bootstrap-corrected C statistic value of 0.78, and a score of at least 6 is strongly predictive (positive predictive value = 73.2%, CI = 59.7% to 84.2%; negative predictive value = 80.7%, CI = 74.3% to 86.1%). The tool scores can indicate three levels of risk: low (≤3), moderate (4 and 5), and high (≥6).[14]

STUDY METHODS

We aimed to implement the use of a perioperative HAPI prevention care bundle and compare the pressure injury incidence rate for patients at risk of developing a pressure injury who received either standard care (ie, no bundle) after procedures or care according to the bundle throughout the perioperative continuum. Therefore, our research question was: How does the use of a care bundle affect perioperative HAPI development?

Design

We designed a single-facility preintervention and postintervention quasi-experimental study that included the care of patients on 15 surgical inpatient nursing units at our facility. The preintervention stage began January 2018 and lasted four months. After we developed the care bundle and then implemented it in January 2019, the postintervention stage lasted 11 months.

We designed a single-facility preintervention and postintervention quasi-experimental study that included the care of patients on 15 surgical inpatient nursing units at our facility.

Inclusion and Exclusion Criteria

Adult patients who were scheduled for an elective procedure, were admitted to any of the 15 surgical inpatient nursing units, had a planned length of stay of at least 24 hours, and were at risk of developing a pressure injury according to the SPURS tool were eligible to participate in this study. Patients who had an existing pressure injury, had previously participated in this study, underwent an emergent procedure, did not plan to remain in the hospital for 24 hours, or were receiving palliative or hospice care were not eligible to participate in this study.

Ethical Considerations and Sampling Technique

We sought approval from the centralized institutional ethics review board before conducting this study; a waiver of written informed consent was approved because of the nature of the study. Using convenience sampling during the study period, staff members in the same-day admission office (ie, the location in which patients register on the day of elective surgery) included all patients scheduled for surgery during the study period who met the inclusion criteria.

Intervention

We reviewed available literature[26-29] to develop the components of our care bundle. Because pressure injury prevention should occur throughout the perioperative continuum of care,[1] we decided bundle use for a specific patient should begin when a patient is admitted for a procedure and continue until patient ambulation or discharge.

Frontline staff member commitment and buy-in for practice changes can be a key challenge to the success of an initiative.[30] Nurse champion involvement early in a pressure injury prevention change process can reduce resistance to the change and influence compliance with the new practice.[31] Before developing the bundle, the principal investigator (F.B.A.B.A.) appointed clinical nurses to a team of unit-based pressure injury prevention champions to work closely with us during the development process. The nurses were proactive and had participated in education activities associated with wound care. The nurse champions also participated in the monitoring and reporting of pressure injury incidence and auditing for compliance after the bundle implementation.

Our care bundle includes educating patients on the importance of frequent repositioning and the rationale of the preventive measures. It also involves providing education information for nurses on properly assessing patients and implementing interventions to prevent pressure injuries. The care bundle interventions are listed in Sidebar 1.

Preparation for care bundle implementation

During six weeks in July and August 2018 before implementing the care bundle, we collaborated with the nurse champions to share information on the bundle initiative with the nursing staff members. The nurse champions also promoted awareness of the new practice bundle and provided information to frontline clinical nurses, especially those who were recently hired.

We ensured the availability of all pressure injury prevention resources before pilot testing the bundle. We worked closely with the clinical nurse manager and the air mattress vendor to review the process of ordering and obtaining alternating air mattresses. We found that more than 24 hours lapsed before an alternating air mattress was delivered for a patient postoperatively. Therefore, we proposed that the vendor store an alternating air mattress at the facility for immediate use, allowing nurses to prepare a mattress before a patient was moved from an OR bed to a hospital bed. The procurement and approval process for our proposal required three months (ie, September to December 2018). During this time, we also collaborated with appropriate vendors and organizational leaders to routinely stock inpatient nursing units with silicone foam dressings and sliding sheets.

Sidebar 1. Perioperative Pressure Injury Prevention Care Bundle Interventions

Preadmission stage: Conduct a risk assessment using the SPURS (surgical pressure ulcer risk score) tool

Preoperative stage: Apply prophylactic foam dressing on high-risk body areas

Intraoperative stage:
- Prevent skin friction and shear
- Protect high-risk pressure areas with padding
- Position properly
- Control moisture
- Monitor core body temperature and prevent hypothermia
- Monitor and maintain adequate hemodynamic status

Postoperative stage:
- Use pressure-redistributing devices
- Use a sliding sheet during transfer and positioning
- Turn every two to three hours
- Encourage early mobilization
- Provide good nutrition (monitor intake and output)
- Optimize postoperative pain management

Because the perioperative HAPI prevention bundle was to be newly implemented across different disciplines, we conducted a pilot testing of the intervention for four weeks in January 2019. The pilot test aimed to evaluate the feasibility of the intervention and identify any changes that may be required before conducting the study.[32] In addition to identifying and resolving device and product concerns, pilot testing allowed us to review performance of pressure injury risk assessments using the SPURS tool to ensure that nurses were completing it accurately and using it to recognize at-risk patients preoperatively. We also monitored patient care in the inpatient nursing units to verify that nurses were implementing the care bundle elements throughout the patient's stay.

Data Collection

During the preintervention period, nurses monitored patients daily for pressure injury development after their procedure until discharge. The nurses reviewed patients' electronic health records thoroughly and then noted a variety of demographic and clinical information, including the results from assessing the patient with the SPURS tool. They also recorded the use of protection and pressure-relieving devices and strategies during patient care and documented pressure injury development according to the National Pressure Ulcer Advisory Panel revised pressure injury staging system.[4] The preintervention data provided the baseline incidence of pressure injuries in the at-risk group.

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During the postintervention data collection period, experienced wound care nurses who had completed a formal wound care course assessed patients for pressure injuries during the perioperative continuum. They used a data collection tool specifically designed to capture key processes in each stage of care to monitor the care bundle compliance. In addition, an audit team led by experienced wound care nurses performed weekly random audits of direct patient care and documentation for one patient on each nursing unit to determine bundle element compliance during the first month after implementation of the intervention. The data associated with the audited patients were also included in the postintervention data collection.

Data Analysis

We entered the collected data into a database for analysis using SPSS software (version 25.0). We reported patients' sociodemographic and clinical data with descriptive statistics to provide an overview of protection and pressure-relieving devices or strategies used when caring for patients. An independent *t* test for normal continuous variables was used to analyze the differences between the preintervention and postintervention groups. Pearson χ^2 analysis was used to examine and identify existing associations of characteristics between patients in both groups on categorical sociodemographic and other covariates (eg, ICU admission, diabetes diagnosis). We also compared the pressure injury incidence rates for both groups and used descriptive statistics to report the compliance rate for the care bundle initiative.

Logistic regression analysis[33] was conducted to evaluate the association between the implementation of the care bundle initiative and pressure injury incidence while adjusting for covariates, including the SPURS and HAPI risk factors[14] (eg, gender, ICU admission, and diabetes). Compared to the postintervention stage, there were no patients with neurologic disease in the preintervention stage; hence, we did not include neurologic disease in the regression model. Results were expressed as odds ratios (ORs) with 95% CI, and significance was set at $P < .05$.

RESULTS

This study included 944 patients (ie, 396 in the preintervention group and 548 in the postintervention group); and there was a significant difference in the number of patients who were 75 years of age or older in the postintervention group (ie, 45.8%) compared to those in the preintervention group (ie, 26.3%) ($P < .001$) (Table 1). More patients in the postintervention group self-identified as female than in the preintervention group ($P < .001$). There were no significant differences in body mass index between the two groups. Significantly fewer patients had a smoking history in the preintervention group ($P < .001$).

Table 1. Demographic Characteristics of Patients in a Study Evaluating a Perioperative Pressure Injury Prevention Care Bundle

Demographic Characteristic	Preintervention (n = 396)	Postintervention (n = 548)	Total (N = 944)	Test of Independence	*P* Value
Age, mean (SD), range, y[a]	65 (14), 21-93	69 (56), 22-104	67 (14), 21-104	$t = -4.29$	<.001
Age, n (%), y					
≤74	292 (73.7)	297 (54.2)	589 (62.4)		
≥75	104 (26.3)	251 (45.8)	355 (37.6)		
Gender, n (%)					
Male	231 (58.3)	221 (40.3)	589 (62.4)	$\chi^2_1 = 29.86$	<.001
Female	165 (41.7)	327 (59.7)	355 (37.6)		
Ethnicity, n (%)					
Chinese	269 (67.9)	417 (76.1)	686 (72.7)	$\chi^2_3 = 9.73$	.02
Indian	49 (12.4)	44 (8.0)	93 (9.9)		
Malay	57 (14.4)	70 (12.8)	127 (13.5)		
Other	21 (5.3)	17 (3.1)	38 (4.0)		
BMI, mean (SD), kg/m^2[a]	25.5 (6.4)	25.6 (6.6)	25.54 (6.5)	$t = -0.15$	.88
BMI category, n (%)					
<23 kg/m^2	156 (39.4)	231 (42.1)	396 (41.9)		
≥23 kg/m^2	240 (60.6)	305 (55.6)	545 (57.7)		
Smoking history, n (%)					
No	297 (75.0)	489 (89.2)	785 (83.2)	$\chi^2_3 = 55.18$	<.001
Yes	21 (5.3)	32 (5.8)	53 (5.6)		
Former smoker	64 (16.2)	27 (4.9)	91 (9.6)		
Undeclared	14 (3.5)	---	14 (1.5)		

NOTE. Significance set at .05. Percentages may not equal 100 because of rounding.
BMI = body mass index.
[a] Independent two-sample *t* test.

The mean SPURS for patients in the postintervention group was greater than 6 (ie, 6.9), a result that placed them in the high-risk stratification category for developing a pressure injury. This result was significantly greater than the mean score of patients in the preintervention group (ie, 5.4) indicating moderate risk ($P < .001$) (Table 2). A comparison of the clinical characteristics for the two groups showed that patients in the preintervention group had longer lengths of stay ($P < .001$) and more admissions to an ICU ($P < .001$) than the patients in the postintervention group. When comparing comorbidities between the two groups, there were significantly more patients in the preintervention group with a diabetes diagnosis ($P < .001$) and significantly more patients in the postintervention group with dyslipidemia ($P = .02$), asthma ($P < .001$), and hypertension ($P < .001$).

Nurses used protective and pressure-relieving strategies (eg, alternating air mattresses, foam dressing on heel, foam dressing on sacral area, and sliding sheets) for patients in the postintervention group ($P < .001$) more frequently than for patients in the preintervention group (Table 3). However, they performed the skin care strategies (eg, application of skin barrier cream) for fewer patients in the postintervention group ($P < .001$).

Pressure injury incidence was lower after the implementation of the care bundle ($P < .001$) (Table 4). The most

Table 2. Clinical Characteristics of Patients in a Study Evaluating a Perioperative Pressure Injury Prevention Care Bundle

Clinical Characteristic	Preintervention (n = 396)	Postintervention (n = 548)	Total (N = 944)	Test of Independence	*P* Value
SPURS, mean (SD)[a]	5.4 (1.8)	6.9 (1.2)	6.3 (3.9)	$t = -14.01$	<.001
Length of stay, median (range), d[a]	9 (4-328)	4 (1-139)	6 (1-328)	$t = 8.40$	<.001
ICU admission (including ICA), n (%)	136 (34.3)	23 (4.2)	159 (16.8)	$\chi^2_2 = 112.9$	<.001
Anemia, n (%)	237 (59.8)	302 (55.1)	539 (57.1)	$\chi^2_1 = 2.11$	.15
Comorbidities, n (%)					
Diabetes diagnosis	174 (43.9)	192 (35.0)	366 (38.8)	$\chi^2_1 = 7.68$	<.001
Stroke	20 (5.1)	22 (4.0)	42 (4.4)	$\chi^2_1 = 0.58$	.45
Neurologic disease	0	30 (5.5)	30 (3.2)	NA	NA
Cardiac disease	70 (17.7)	113 (20.6)	183 (19.4)	$\chi^2_1 = 1.28$	.26
Renal disease	72 (18.2)	122 (22.3)	194 (20.6)	$\chi^2_1 = 2.35$	.13
Dyslipidemia	123 (31.1)	212 (38.7)	335 (35.5)	$\chi^2_1 = 5.84$	.02
Asthma	15 (3.8)	56 (10.2)	71 (7.5)	$\chi^2_1 = 13.67$	<.001
Vascular disease	30 (7.6)	46 (8.4)	76 (8.1)	$\chi^2_1 = 0.21$	.65
Hypertension	234 (59.1)	380 (69.3)	614 (65.0)	$\chi^2_1 = 10.63$	<.001
Respiratory disease	10 (2.5)	12 (2.2)	22 (2.3)	$\chi^2_1 = 0.11$	.74

NOTE. Significance set at .05.
SPURS = surgical pressure ulcer risk score; ICU = intensive care unit; ICA = intermediate care area; NA = not applicable.
[a] Independent two-sample *t* test.

common sites for development of pressure injuries in both groups were the sacral and coccygeal areas; almost all of the pressure injuries were either stage 1 (ie, nonblanchable erythema of intact skin[4]) or stage 2 (ie, partial-thickness skin loss[4]).

The adjusted OR for the development of pressure injuries in our study was 2.17. After adjusting for the significant covariates (ie, gender, SPURS, ICU admission, and diabetes comorbidity), there was no significant difference between the probability of HAPI occurring between the two groups of patients ($P = .21$).

A physical and a medical record random audit of 105 patients showed good documentation of SPURS and the use of prophylactic foam dressings (Table 5). However, 24% of the foam dressings were not being applied properly.

DISCUSSION

Prevention and management of pressure injuries require effective communication and teamwork among the interdisciplinary teams in the clinical setting.[1] Pressure injury prevention is a nursing priority and pressure injury rates are a key performance indicator of nursing care quality at our facility. At the time of our study, HAPI-prevention practices at our facility involved inconsistent postoperative use of pressure-relieving devices and preventive initiatives based on patients' risk factors. Therefore, an evidence-based care bundle had the potential to optimize perioperative HAPI prevention, especially for patients who were at an increased risk for a pressure injury. We evaluated the effectiveness of the bundle, which was easily replicable across the nursing units. We believe that ongoing monitoring and updating the care bundle to include the latest evidence are essential components of the pressure injury prevention initiative's sustainability and success.

Table 3. A Comparison of Protective and Pressure-Relieving Devices and Strategies in a Study Evaluating a Perioperative Pressure Injury Prevention Care Bundle (N = 944)

Protective and Pressure-Relieving Devices and Strategies	Preintervention (n = 396)	Postintervention (n = 548)	χ^2	*df*	*P* Value
Alternating air mattress					
No	368 (92.9)	329 (60.0)			
Yes	28 (7.1)	219 (40.0)	128.7	1	<.001
Foam dressing on heel					
No	391 (98.7)	209 (38.1)			
Yes	4 (1.0)	339 (61.9)	368.4	2	<.001
Not documented	1 (0.3)	0			
Foam dressing on sacral area					
No	347 (87.6)	165 (30.1)			
Yes	49 (12.4)	383 (69.9)	306.4	1	<.001
Heel bootie					
No	385 (97.2)	535 (97.6)			
Yes	9 (2.3)	13 (2.4)	2.8	2	.4
Not documented	2 (0.5)	0			
Sliding sheet					
No	87 (22.0)	439 (80.1)			
Yes	37 (9.3)	109 (19.9)	532.4	2	<.001
Not documented	272 (68.7)	0			
Overlay					
No	0	474 (86.5)			NA
Yes	0	74 (13.5)	NA	NA	NA
Positioning wedges					
No	350 (88.4)	470 (85.8)			
Yes	46 (11.6)	78 (14.2)	1.4	1	.2
Turning every two hours					
No	212 (53.5)	272 (49.6)			
Yes	170 (42.9)	276 (50.4)	22.7	2	.9
Not documented	14 (3.5)	0			
Skin care					
No	264 (66.7)	480 (87.6)			
Yes	131 (33.1)	68 (12.4)	60.8	2	<.001
Not documented	1 (0.3)	0			

NOTE. Significance set at .05. Percentages may not equal 100 because of rounding.
NA = not applicable.

Patients in the postintervention group experienced significantly fewer pressure injuries than patients in the preintervention group (1.6% versus 4.8%, $P < .001$). However, the OR was nonsignificant and, thus, the bundle may not offer a clinically relevant difference in the odds of developing a HAPI.

Table 4. Pressure Injury Incidence Before and After Implementation of a Perioperative Pressure Injury Prevention Care Bundle (N = 944)

Pressure Injury Information	Preintervention (n = 396)	Postintervention (n = 548)	Test of Significance	*P* Value
Developed	19 (4.8)	9 (1.6)	$\chi^2_1 = 8.0$	<.001
Site[a]				
Sacral and coccygeal areas	15 (3.8)	7 (1.3)	NA	NA
Heel	0	1 (0.2)	NA	NA
Iliac crest	0	1 (0.2)	NA	NA
Other (ie, nose, penis)	4 (1.0)	0	NA	NA
Stage[a]				
1 (nonblanchable erythema of intact skin)[1]	11 (2.8)	6 (1.1)	NA	NA
2 (partial-thickness skin loss)[1]	5 (1.3)	3 (0.5)	NA	NA
3 (full-thickness skin loss)[1]	0	0	NA	NA
4 (full-thickness skin and tissue loss)[1]	2 (0.5)	0	NA	NA
Deep tissue injury[a] (persistent nonblanchable deep red, maroon, or purple discoloration of intact or nonintact skin)[1]	1 (0.3)	0	NA	NA

NOTE. Significance set at .05.
NA = not applicable.
[a] Calculated on number of patients in the preintervention or postintervention group.

Reference

1. *Edsberg LE, Black JM, Goldberg M, McNichol L, Moore L, Sieggreen M. Revised National Pressure Ulcer Advisory Panel pressure injury staging system. Revised pressure injury staging system.* J Wound Ostomy Continence Nurs. *2016;43(6):585-597.* https://doi.org/10.1097/won.0000000000000281

The most common pressure injury sites in patients in our study were the sacral and coccygeal areas, a finding that aligns with published study results.[34-36] In addition, we found that the most frequent pressure injury stages were 1 and 2, which also aligns with published study results.[34,35]

Table 5. Random Audit Results of Compliance With Care Bundle Interventions After Implementation (N = 105)

Protection and Pressure-Relieving Devices and Strategies	Compliance, n (%)
SPURS documentation	79 (75.2)
Foam dressing applied to heels	88 (83.8)
Foam dressing applied to sacral area	89 (84.8)
Foam dressing applied properly	80 (76.2)

SPURS = surgical pressure ulcer risk score.

The timely identification of risk factors associated with pressure injury development can be crucial in effective prevention.[37] We used the SPURS tool to identify patients who were at risk for pressure injury development. The postintervention group patients with scores indicating risk for pressure injury development had a significantly higher mean SPURS (mean [SD] = 6.9 [1.2], $P < .001$) than patients in the preintervention group. The use of the SPURS prediction tool enabled a more stringent determination of patients' risk of pressure injury in the preoperative stage and nurses could implement care bundle elements to prevent injury for patients who had increased scores.

Protection and Pressure-Relieving Devices

The overall increased use of various protection and pressure-relieving devices (eg, alternating air mattress, foam dressing) for patients in the postimplementation

group may have contributed to the lower pressure injury incidence. Results of a systematic literature review with meta-analysis included moderate-certainty evidence that "powered active air surfaces and powered hybrid air surfaces probably reduce the incidence of pressure ulcers by 58% and 78% on average, respectively."[38(p24)] When compared to a standard hospital mattress, an alternating air pressure mattress with different interface pressures provided periodic temporary relief of pressure, thereby reducing skin functional and structural changes.[39] Alternating air pressure mattresses also were more effective than alternating air pressure overlays on standard mattresses.[40]

Results of a 2015 systematic literature review with meta-analysis showed that the use of an unspecified foam dressing significantly reduced pressure injuries when compared to a hydrocolloid dressing (relative risk = 0.16; 95% CI = 0.07 to 0.38).[41] Two additional studies showed that soft silicone border foam dressings significantly reduced the risk of intraoperatively acquired pressure injuries (OR = 0.23, 95% CI = 0.05 to 0.79, $P = .019$).[42] When compared to an ICU control group that did not involve use of a silicone border foam dressing intervention, patients in the intervention group experienced significantly fewer pressure injuries (6% versus 46%, $\chi^2 = 21.722$, $P < .001$).[43] In the direct patient observations and review of the health records in the random audit conducted in our study, only 76.2% of the prophylactic silicone foam dressings were documented as having been applied correctly, which warrants an improvement in the application techniques. Prophylactic silicone border foam dressings can protect the skin from urine and feces.[44]

Leaders and Unit-Based Nurse Champions

Results of a qualitative descriptive study show that successful implementation of a pressure injury prevention care bundle required awareness of the initiative and how it compared to current practices, feasibility of implementation with appropriate communication and participation, acceptability of changed practices, identification of perceived barriers to implementation, and the ease of administration of interventions in the nurses' daily work routine.[45] For our facility, these elements required leaders to communicate and disseminate information about changes effectively to the main stakeholders (eg, nurses, surgeons, patients). Support from organizational leaders enabled pressure injury prevention to be operationalized more consistently across stakeholders.

The unit-based clinical nurse champions contributed to the evidence-based care bundle design and supported the initiatives. They also led and monitored the care processes on their respective nursing units. Unit-based champions[31] and nurse-driven initiatives[30] can influence nurses to improve clinical outcomes, such as decreasing pressure injury incidence. Additionally, to ensure compliance with the care bundle, the nurse champions continue to monitor adherence to bundle elements monthly.

Unit-based champions and nurse-driven initiatives can influence nurses to improve clinical outcomes, such as decreasing pressure injury incidence.

Patient Participation

Patients' active participation and strict adherence to maintaining the prophylactic dressings applied for them (eg, leaving the dressings intact) also helped in further adaptation and integration of the pressure injury prevention care bundle into the care practices. The key element of educating patients on the importance of the pressure injury prevention measures empowered them to become involved in their care during a hospital stay. Such interventions should be initiated at an appropriate time before surgery and should involve an effective approach and education tools to support patient learning.[46]

LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Our study results have limited generalizability because the data were obtained at only one facility. Patients who underwent emergent procedures were not evaluated in this study; however, they may have different health conditions than those who undergo elective procedures, and they also may require ICU care. Patients in ICUs can experience hemodynamic instability that requires treatment with vasoactive medications; they also may require ventilator assistance and sedation medications.[47] Therefore, we were unable to generalize the findings of this study to patients who underwent emergent procedures, and a multisite study that includes and examines the effectiveness

Key Takeaways

- Perioperative patients are at risk for development of pressure injuries that may not be identified until a few days after surgery. The treatment of such injuries is costly and time-consuming.
- Recognizing an increase in pressure injuries at a facility in Singapore, researchers sought to develop a care bundle and study its effects on perioperative pressure injury rates. They collaborated with a team of nurse champions to develop a care bundle that included elements for the four stages of perioperative care (ie, preadmission, preoperative, intraoperative, postoperative).
- Bundle elements included educating patients on pressure injury prevention as needed throughout the perioperative continuum, performing a risk assessment and applying silicone foam dressings preoperatively, maintaining hemodynamic status and normothermia intraoperatively, and using pressure-relieving devices and mobilizing early postoperatively.
- After implementing the bundle, the pressure injury incidence rate decreased from 4.8% to 1.6% ($P < .001$). However, no significant difference was found regarding the probability of pressure injuries occurring between the preintervention and postintervention groups. Additional research with a control group and multiple sites is needed to determine the clinical relevance of the pressure injury prevention care bundle.

of the care bundle for preventing perioperative pressure injuries for these patients is needed.

Unlike randomized controlled trials, quasi-experimental study design is subject to selection bias; however, in our study, the selection of patients was based on their pressure injury risk status using the SPURS tool, which may mitigate the selection bias.[48] Another common limitation of quasi-experimental study design is the lack of a comparison or control group, which limits the cause-and-effect relationship.[49] Furthermore, we are uncertain if the results of the intervention were confounded by the Hawthorne effect in which participants change their behavior because they are involved in a study. Therefore, future studies could include a control group to establish the causal relationship.

Another limitation of this study was the difference and unequal baseline distribution between the preintervention and postintervention groups, which could have influenced the outcome. Propensity score matching of baseline confounding variables between groups may be considered in future studies to generate more accurate interpretations.

In addition, we were unable to ascertain the relevance of the care bundle as there was no significant difference found between the probability of HAPI occurring between the two groups of patients. This warrants additional future research with a control group and multiple sites. Although our care bundle included best-practice evidence, there was also an element of patient participation associated with pressure injury prevention. Because of the limited time available preoperatively to educate patients on pressure injury prevention, it is possible that patients may not actively engage unless the concepts are reinforced postoperatively. As part of the process evaluation for the care bundle implementation, patients' perspectives on the usefulness and effect of pressure injury prevention with the bundle in clinical practice should be explored in future studies.

Finally, we did not consider the patients' pain score during this study. Pain may affect the need for repositioning of the patients and may contribute to pressure injury prevention.[50] Additional studies are needed on the relationship between postoperative pain management and pressure injury development.

CONCLUSION

During this study, we sought to develop and implement a perioperative HAPI prevention care bundle. We included the SPURS prediction tool in the bundle to promote early identification of at-risk patients preoperatively to facilitate implementation of pressure injury prevention measures earlier. Patients in the postintervention group experienced fewer pressure injuries than those in the preintervention group. Involvement of unit-based nurse champions during development of the

care bundle and subsequently likely facilitated increased compliance to the risk assessment documentation and proper application of prophylactic foam dressings to high-risk areas (eg, heels, sacral area). Use of the bundle has the potential to improve perioperative HAPI prevention, but will require a more rigorous study design in future studies.

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