Perioperative Pressure Injuries: A Descriptive Study of Patient Characteristics

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ABSTRACT

OBJECTIVE: The perioperative setting presents unique challenges that contribute to the development of pressure injury (PI). In this study, the authors explore the incidence and baseline characteristics of perioperative patients (adult, inpatient, and surgical patient population with at least 3 days' hospital stay) who undergo surgery and have PI outcomes.

METHODS: This descriptive retrospective study was conducted using electronic medical record data of 55,270 patients from an academic health care system. Differences in baseline characteristics between patients with versus without PI were examined using the Fisher exact test, χ^2 tests, and *t* tests.

RESULTS: The incidence of perioperative pressure injury (PPI) was 0.5%. Of the PPI group, 65.7% developed PPI after cardiovascular surgery. The most prevalent PPI stage was unstageable, followed by Stage 2 and deep tissue injury. The most common locations for PPI were the back, followed by the buttocks and heels. The PPI group was older and had a higher average comorbidity score ($P < .001$). Comorbidity differences of those with and without PPI were observed in congestive heart failure (28.1% vs. 15.2%, $P < .001$), diabetes (28.5% vs. 19.2%, $P < .001$), renal disease (27.7% vs. 18.8%, $P < .001$), and severe liver disease (8.0% vs. 3.4%, $P < .001$). There were no differences in race, body mass index, or history of tobacco use between the PPI group and the non-PPI group.

CONCLUSIONS: This study identified that cardiovascular surgery remains a high risk for PPI in perioperative patients. Among the demographic characteristics, race is not a sufficient category for identifying risk for PPI as it lacks the accuracy in skin tone measurement.

KEYWORDS: characteristics, charlson comorbidity index, incidence, perioperative, pressure injury, risk factors

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INTRODUCTION

Pressure injuries (PI), commonly known as pressure ulcers or bedsores, arise from a combination of mechanical and biological factors and prolonged pressure on the skin and underlying tissues. These injuries pose significant risks during the perioperative period, which spans before, during, and after surgery. In addition, intrinsic factors such as advanced age, nutritional status, and physical condition contribute to their occurrence.[1–3]

The perioperative setting presents unique challenges that contribute to the development of PI. Factors such as comorbidities, advanced age, malnutrition, and impaired tissue perfusion further increase patients' vulnerability to PI during this critical period.[2,4,5] Patients may experience prolonged immobility during surgery and positioning on operating tables, coupled with restricted mobility postoperatively due to pain, anesthesia effects, or surgical site limitations. There is insufficient recent literature on specific statistics of perioperative pressure injuries (PPI); however, the rates range between 2.3% and 44%.[6,7] In the United States, according to a prevalence of surgery study based on 2018 National Health Interview Survey data, 1 in 9 persons reported having surgery at least once in 2017.[8] There is a trend of increased outpatient surgeries with higher proportions of comorbidities.[9]

The consequences of PPI extend beyond the immediate postoperative period, potentially leading to prolonged hospital stays, increased health care costs, and decreased quality of life for patients.[10,11] Furthermore, these injuries can contribute to postoperative complications such as infections, delayed wound healing, and impaired functional recovery, thereby impacting surgical outcomes and patient satisfaction.[12–14]

Objective

In this descriptive study, the authors explore the incidence of perioperative patients admitted to the hospital who have had surgery and sustained PPI. An additional aim was to discover the commonness of age, race, sex, and surgery type, and identify PPI stages and locations. The Charlson Comorbidity Index (CCI), body mass index (BMI), and tobacco use among the patients were also investigated as potential related risk factors.

The research question was, "What are the incidence rate and baseline characteristics of perioperative patients (adult, inpatient, and surgical patient population with at least 3 days' ' hospital stay) who undergo surgery and have pressure injury outcomes?"

Conceptual Schema

The framework suitable for this study is the Conceptual Schema for PI Development in Critically Ill Patients (Conceptual Schema).[15] The Conceptual Schema underlines the etiological bases of PI and identifies conditions as static intrinsic, dynamic intrinsic, and dynamic extrinsic factors, particularly relevant in the context of perioperative care (Figure 1). This conceptual schema integration has the potential to inform clinical practice and guide future research initiatives aimed at improving patient care and perioperative outcomes.

The Conceptual Schema categorizes age, smoking, and baseline mobility limitations as static intrinsic factors. These are pre-existing health conditions that influence an individual's susceptibility to PI during the perioperative period. The dynamic intrinsic factors include prolonged perioperative time, impaired mobility, and chemical paralysis from anesthesia and are reflected by intraoperative hypertension, hypoxia/respiratory failure, and hemodynamic instability.

Alderden et al[16] found this framework aligned with their exploration of factors in PI development in the intensive care units. The physiological parameters of critical illness were

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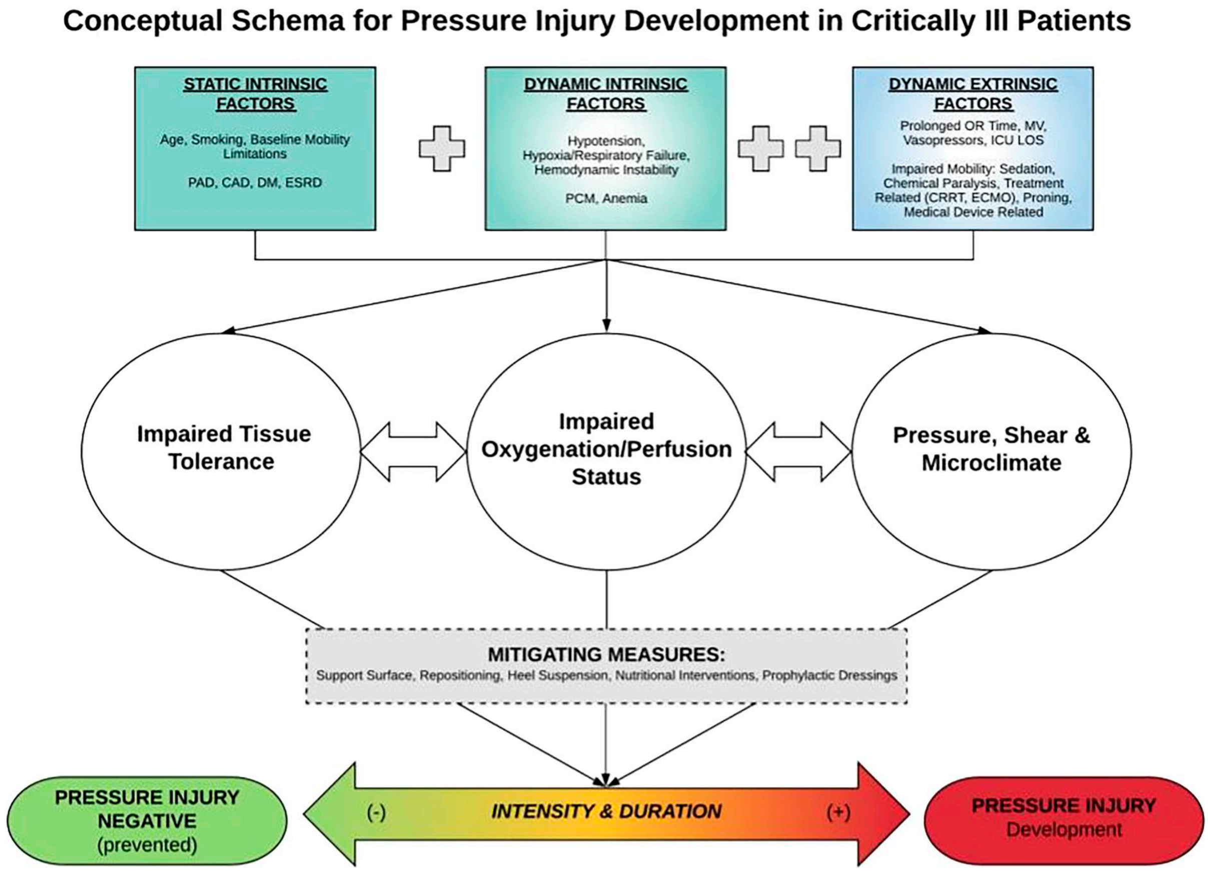

FIGURE 1. CONCEPTUAL SCHEMA FOR PRESSURE INJURY DEVELOPMENT IN CRITICALLY ILL PATIENTS
+ = increased risk; ++ = cumulative increased risk; CAD, coronary artery disease; CRRT, continuous renal replacement therapy; DM, diabetes mellitus; ECMO, extracorporeal membrane oxygenation; ESRD, end stage renal disease; ICU, intensive care unit; LOS, length of stay; MV, mechanical ventilation; OR, operating room; PAD, peripheral artery disease; PCM, protein-calorie malnutrition. Reproduced with permission, Cox and Schallom.[15]

depicted by decreased oxygen delivery to tissues within the schema's category of dynamic intrinsic factors. The framework guided our study's exploration of how various patient characteristics and factors contribute to the incidence of PPI, allowing for a comprehensive understanding of this complex issue.

METHODS

This descriptive retrospective study was conducted using electronic medical record data of patients in the acute care setting at an academic health care system. The 622-bed facility is a level 1 Trauma Center that supports its own hospital-based helicopter emergency trauma service in Northern California. At this setting, the country's first successful human heart transplant and the world's first combined heart-lung transplant were performed. The hospital is an American Nurses Credentialing Center Magnet-recognized organization. In fiscal year 2024, more than 47,000 surgeries were performed at the facility.

Patient positioning policies were created based on the Association of periOperative Registered Nurses (AORN) guidelines[17] and updated periodically to reflect current evidence. Before May 2017, the standard practice to prevent PPI for patients who underwent surgery longer than 3 hours included applying multilayer silicone foam dressings to pressure points (ie, sacrum). After May 2017, an air-inflated static seat cushion under the sacral area was adopted standard practice for all patients with surgery longer than 3 hours in the supine position. In the operating rooms, the surgical table pads vary per manufacturer and are not standardized throughout and were replaced per recommendations.

For this project, the authors accessed deidentified data on more than 3.2 million unique patients from both ambulatory care and inpatient settings. Available data included demographics, diagnosis, procedure codes, and PPI stages and locations. Electronic health records were implemented in 2015 at the health care system; therefore, study data were restricted to encounters between January 1, 2015, and December 31, 2023.

Eligible patients were adults aged 18 to 90 years who had surgery with an inpatient stay of at least 3 days. Surgical patients were excluded if they ever had a prior PI diagnosis, if they were ever diagnosed as wheelchair bound, bedridden, or paralyzed (eg, hemi/paraplegia), based on International Classification of Diseases (ICD) and Current Procedural Terminology codes assigned to prior medical encounters. Patients were also excluded if they had <3 months of medical records prior to surgery, and if they did not have at least one medical encounter during those 3 months. Among eligible surgical patients, PI was defined based on ICD Version 9 (ICD-9) or Version 10 (ICD-10) codes assigned during the postsurgical inpatient stay.

The authors used demographic records to define patients' age at admission, sex, race, and ethnicity. Comorbid illnesses and tobacco use were defined from ICD codes. Comorbid illnesses included those defined by the CCI as implemented by Quan and colleagues.[18–21] Body mass index was defined from vital statistics. Surgical procedures were categorized based on body system, as cardiovascular, digestive, nervous, respiratory, or other. The authors evaluated for CCI at the time of admission and procedures during the 3 months before admission as indicators of health status.

The authors compared the distribution of baseline characteristics between surgical patients with and without PI using proportions for binary or discrete variables and means for continuous variables. They then tested for significant differences in baseline characteristics between patients with versus without PI using Fisher exact test (for binary variables) and χ^2 tests (for discrete variables), or *t* tests (for continuous variables). Analysis was completed using R version 4.2 (Atropos Health).

For the protection of human subjects and data integrity, approval from the Institutional Review Board was obtained. Deidentified data were obtained and secured according to institutional policy.

RESULTS

The study cohort, comprised of 55,270 patients, was admitted between 2015 and 2023. Only 274 patients developed PPI, compared with 54,996 patients who had never had a PPI. The overall incidence rate of PPI was 0.5%. Approximately 58.6% of the cohort were White, 57.0% were 60 years of age or older, and 51.5% were female (Table 1).

Of the PPI group, 65.7% developed PPI after cardiovascular surgery (Table 2). The most prevalent PPI stage was unstageable, followed by Stage 2 and deep tissue injury (Table 3). The most common locations for PPI were the back, followed by the buttocks and heels (Table 4).

Overall, the mean age in the PPI group was 65.7 years compared with the mean age of 60.2 years among non-PPI patients ($P < .001$). The PPI group consisted of 13.9% Asians and 5.1% Blacks, whereas the non-PPI group consisted of 16.8% Asians and 4.2% Blacks. Male patients made up 51.8% of the PPI group, whereas they represented 48.5% of the non-PPI group (Table 1). The average comorbidity score was 6.0 in the PPI group compared with 4.7 in the non-PPI group ($P < .001$). Comorbidity differences of those with and without PPI were observed in congestive heart failure (28.1% vs. 15.2%, $P < .001$), diabetes (28.5% vs. 19.2%, $P < .001$), renal disease (27.7% vs. 18.8%, $P < .001$), and severe liver disease (8.0% vs. 3.4%, $P < .001$), respectively (Table 5). There were no differences in baseline BMI or history of tobacco use between the PPI group and the non-PPI group.

TABLE 1. DEMOGRAPHIC CHARACTERISTICS OF SURGICAL PATIENTS WITH AT LEAST 3 DAYS' HOSPITAL STAY, STRATIFIED BY PRESENCE OR ABSENCE OF PI

Demographic Characteristics	No PI	PI	*P*
Total N	54,996	274	
Female (%)	28,331 (51.5)	132 (48.2)	.27
Mean age, y (SD)	60.2 (16.6)	65.7 (13)	< .001
18-29	3230 (5.9)	3 (1.1)	
30-39	5037 (9.2)	9 (3.3)	
40-49	5722 (10.4)	23 (8.4)	
50-59	9698 (17.6)	41 (15)	
60-69	13,931 (25.3)	86 (31.4)	
70-79	11,984 (21.8)	80 (29.2)	
80-89	5394 (9.9)	32 (11.7)	
Race			.542
White	32,236 (59)	166 (61)	
Other	11,220 (20)	56 (20)	
Asian	9243 (17)	38 (14)	
Black	2297 (4.2)	14 (5.1)	
Hispanic	9284 (17)	45 (16)	.84

Note: Values are either count with proportion or mean with SD. Statistical significance was declared for a *P* value < .001.

Abbreviation: PI, pressure injury.

DISCUSSION

Multiple studies have identified the risk factors associated with PPI, particularly in demographic categories such as age, gender, race, BMI, history of tobacco use, and comorbidity; however, findings are inconsistent.[1,3,5] The present study found that the PPI group had a higher average age, a higher CCI, and higher comorbid diabetes, congestive heart failure, renal disease, and severe liver disease. No difference in gender, race, BMI, or history of tobacco use between the PPI group and the non-PPI group was noted.

When examining the age distribution results from Aloweni et al[22] and Yang et al[21] in comparison with the present study, several key findings emerge. Aloweni and colleagues reported a significant prevalence of PPI in older age brackets, with 41.13% of participants aged 45 to 64 and 24.83% aged 75 or above, with a *P* value of < .0001 indicating strong statistical significance. In Yang and colleagues, 54.2% of the PPI group were aged ≤ 74, whereas 45.8% were aged ≥ 75, highlighting a notable increase in PPI among older adults. In the present study, the mean age of the PPI group was 65.7 years (SD = 13), with the largest PPI group being those aged 60 to 69, comprising 31.4%.

The CCI is a valuable tool for predicting patient outcomes and informing preventative strategies.[23,24] Higher CCI scores are associated with increased risks of complications, including PPI, longer hospital stays, and higher mortality rates.[25–27] Understanding a patient's CCI allows clinicians to develop tailored preventative bundles based on specific comorbidities. For instance, patients with high scores due to diabetes may benefit from enhanced glycemic control protocols, whereas those with cardiovascular disease may require rigorous monitoring of blood pressure.

Although some studies have identified female sex as a contributing factor, Aloweni and colleagues found no significant difference between individuals with and without PPI. Similarly, Yang and colleagues reported a slightly higher prevalence of females in both the PPI (52%) and non-PPI (56%) groups; however, this difference was not statistically significant, with a *P* value of .18. In the present study, sex was also deemed not statistically significant, with a *P* value of .27; specifically, 51.5% in the non-PPI group were female, compared with 48.2% in the PPI group.

There is growing recognition of the necessity for inclusive representation of diverse skin tones, highlighting the importance of considering these factors in PI prevention and care practices.[28,29] Race is a social construct, whereas skin tones are physical characteristics. Race is not sufficient for observing potential PPI risk factors related to skin tone.[30–32] The application of a standardized assessment and classification would be more objective data to explore in PPI research.[33,34] In addition, when documenting race in the health record, the broad classification of "other" is an erosion of specificity and fails to acknowledge the distinct cultural, historical, and social contexts that contribute to health disparities. By relegating

TABLE 2. SURGERY TYPES

Surgery Category	No PI, n (%)	PI, n (%)
Cardiovascular	20,155 (36.6)	180 (65.7)
Unspecified surgical category	31,426 (57.2)	84 (30.7)
Respiratory	266 (0.5)	4 (1.5)
Digestive	1182 (2.2)	3 (1.1)
Musculoskeletal	1284 (2.3)	2 (0.7)
Nervous	683 (1.2)	1 (0.4)

Abbreviation: PI, pressure injury.

individuals to the "other" category, specific racial and ethnic identities are marginalized or rendered invisible in health data.

From the authors' extraction of 55,270 electronic medical records, the overall incidence of PPI was 0.5%. A systematic review examining 17 articles with a total of 5451 patients showed the incidence of PPI ranged from 0.3% to 57.4%.[35] Other studies showed the incidence of PPI ranged from 1.3% to 42.32%.[1,5,36,37] The wide range of PPI incidence is potentially related to the difference in study design, type of surgery, and inclusion/exclusion criteria. The design of this study, utilizing electronic medical records, provides the opportunity to take a large amount of health care data to identify useful and understandable patterns. If cases are underreported or misclassified, this could lead to a lower incidence rate in our findings. The accuracy and completeness of the data may also contribute to the low rate.

The present results indicated that the PPI incidence rate was much higher in the cardiovascular surgery population compared with other types of surgery, highlighting the cardiovascular surgery population as having a higher PPI risk due to their prolonged surgical procedure and complex comorbidities.[4,35,37] These findings are consistent with 2 systematic reviews that showed patients undergoing cardiac surgery are considered among the highest-risk populations for PPI.[38,39]

Kim and Lee[5] found the coccyx and back were the most common sites for PPI development, and all PPI were either Stage 1 or Stage 2.[5] In their study, 10.1% of all PPI progressed to Stage 2 or 3 after 14 days of observation. The data presented in this study from ICD-9 and ICD-10 codes showed that the back and buttocks were the most common PPI sites (82.7% combined). Because of the retrospective method of this study, the progression of PI was not observed. However, 47.3% of PPI presented as full-thickness tissue damage (Stage 3, Stage 4, and unstageable) upon discharge.

Despite diligent prevention efforts, the development of PI may be inevitable[33] because of illness severity, comorbidities, or the nature of surgical treatments. This calls for careful clinical judgment regarding individual patient situations. Clearly identifying the site and stage of PI will aid in the determination of avoidable versus unavoidable PI, and classification of PPI versus inpatient unit PI.

TABLE 3. PERIOPERATIVE PI CLASSIFICATION

PI Stage Confirmed by ICD 9 and 10	No. Perioperative PI, n (%)
Unstageable	60 (28.7)
Stage 2	53 (25.4)
Deep tissue injury	35 (16.7)
Stage 3	31 (14.8)
Stage 1	22 (10.5)
Stage 4	8 (3.8)

Note: Unspecified stage excluded.
Abbreviations: ICD, International Classification of Diseases; PI, pressure injury.

TABLE 4. PERIOPERATIVE PI SITE

PI Site Confirmed by ICD 9 and 10	No. Perioperative PIs, n (%)
Back	189 (68)
Buttock	41 (14.7)
Heel	23 (8.3)
Head	12 (4.3)
Hip	7 (2.5)
Ankle	4 (1.4)
Elbow	2 (0.7)

Note: Unspecified site excluded.
Abbreviations: ICD, International Classification of Diseases; PI, pressure injury.

Emerging technologies in the operating room such as navigation and robotics have been identified as helpful, however, at the cost of increasing surgical time.[40,41] Time undergoing surgery is the most common risk factor associated with PPI.[6,42–47] At academic health care systems, surgery times may be even longer, given the learning environment for both anesthesia and surgeon providers. Although surgical time was not measured in the collected data, the cardiac procedure times are typically longer.

Empirical Support of Conceptual Schema

The Conceptual Schema effectively provided a framework for understanding the multifactorial etiology of PI in the perioperative context.

This study acknowledges both static intrinsic factors (such as advanced age and pre-existing medical conditions) and dynamic intrinsic factors (like physiological responses to surgery) as characteristics contributing to a patient's susceptibility to PPI outcomes. Factors such as age, CCI, and

TABLE 5. CLINICAL CHARACTERISTICS OF SURGICAL PATIENTS WITH AT LEAST 3 DAYS' HOSPITAL STAY, STRATIFIED BY PRESENCE OR ABSENCE OF PI

Clinical Characteristic	No PI	PI	*P*
Charlson Comorbidity Index (SD)	4.7 (3.6)	6.0 (3.7)	<.001
Comorbidities (%)			
Diabetes	10,538 (19.2)	78 (28.5)	<.001
Congestive heart failure	8371 (15.2)	77 (28.1)	<.001
Renal disease	10,317 (18.8)	76 (27.7)	<.001
Severe liver disease	1870 (3.4)	22 (8.0)	<.001
Malignancy	19,307 (35.1)	94 (34.3)	.782
Chronic pulmonary disease	10,851 (19.7)	60 (21.9)	.369
Mild liver disease	7416 (13.5)	50 (18.2)	.021
Peripheral vascular disease	6416 (11.7)	40 (14.6)	.132
Metastatic solid tumor	5,450 (9.9)	37 (13.5)	.047
Diabetes with complications	4400 (8.0)	36 (13.1)	.002
Cerebrovascular disease	5664 (10.3)	35 (12.8)	.179
Myocardial infarction	3547 (6.5)	27 (9.9)	.022
Rheumatic disease	2255 (4.1)	15 (5.5)	.253
Peptic ulcer disease	1525 (2.8)	10 (3.7)	.378
Dementia	847 (1.5)	4 (1.5)	>.999
HIV	169 (0.3)	1 (0.4)	>.999
Hemiparaplegia	168 (0.3)	0 (0)	.36
BMI	28.1 (6.4)	27.1 (7)	.018
Tobacco use	3047 (5.5)	10 (3.6)	.171

Note: Values are either count with proportion or mean with SD. Statistical significance was declared for a *P* value <.001.
Abbreviations: BMI, body mass index; PI, pressure injury.

comorbidities (diabetes, congestive heart failure, renal disease, and severe liver disease) had the highest percentages among the PPI patients.

Central to the conceptual schema is the notion that compromised oxygenation and perfusion are pivotal in many risk factors associated with PI development. This notion provides a biological basis that complements the understanding of perioperative patient PI outcomes.

The study results emphasize the importance of environmental and care-related factors, such as surgical positioning and mobility restrictions, which can exacerbate the risk of PI during the perioperative phase.

Incorporating this conceptual schema enhances the study's theoretical foundation, illustrating the complexity of PI development and providing a holistic approach to understanding and preventing these injuries within the perioperative population.

Limitations

This study has several limitations that should be acknowledged. A primary limitation is the lack of patient care data collection, which prevented us from identifying specific operating room conditions and the types of surgical table pads utilized during procedures. As a result, the authors were unable to assess how variations in surgical table pads and their properties may have influenced PPI outcomes. The absence of this critical data restricts the authors' ability to draw definitive conclusions regarding the impact of specific equipment on the development of PPI.

The study setting was a single academic health care system, limiting the generalizability of the findings. Retrospective data collection restricted learning about patient care that may have contributed to PPI prevention and development. Classification of PPI, based on the appearance of selected ICD-9 and ICD-10 codes, may have influenced findings. Clinical observations would have validated the diagnosis codes and provided PPI staging.

Nursing Implications

To enhance patient outcomes and reduce the risk of PPI, it is essential to implement comprehensive health promotion strategies and effectively manage comorbidities prior to surgery, particularly for potentially elective procedures. This involves optimizing chronic conditions such as diabetes, obesity, and cardiovascular disease through regular monitoring of blood glucose levels for diabetic patients, implementing weight management programs that incorporate nutritional counseling and physical activity, and promoting cardiovascular health through blood pressure management and circulation enhancement strategies.

In addition, educating patients and caregivers on the importance of maintaining optimal health before surgery is crucial. This includes understanding the significance of glycemic control, weight management, and cardiovascular health in reducing surgical risks. Providing guidance on the importance of regular repositioning at least every 2 hours and the use of pressure-relieving devices before and after surgery can further help prevent PPI.

The risk factors identified in this study can influence clinical practice on PPI prevention before and after surgery. Commonly used risk assessment instruments include age, BMI, ASA score, estimated surgery time, type of surgery, and surgical position.[48–52] However, based on these findings, CCI should be considered as a complement to current PPI assessment instruments to guide clinical practice. Health care systems should implement quality improvement initiatives that utilize CCI scores to stratify patients and apply targeted interventions, such as nutritional support and mobility programs, aimed at reducing the risk of PPI and other complications. Clinical guidelines often recommend using the CCI to assess patient risk and guide management strategies.

Clinical nurses can encourage patients to alleviate pressure points before and after surgeries and take into consideration the procedure type and individual risk factors to plan individualized care. Close monitoring and proper pressure-reducing interventions before, during, and after surgery are critical to prevent PPI deterioration.[39]

Nurse leaders should promote collaboration and care coordination between the wound care department, inpatient nursing units, and perioperative areas. Nursing education focusing on surgical positioning and signs and symptoms of PPI aids in early identification. Staff education should also include routine training on skin assessment, patient positioning techniques, and pressure-relieving devices.

Currently, there is no systematic way to collect PPI incidents. Data from ICD-9 and ICD-10 codes provide PI information on stage and location, but not on unit classification. The lack of national data reporting of PPI limits data comparison and opportunities for quality improvement. It would be beneficial to include PI classification in ICD-10 data and the National Database of Nursing Quality Indicators Pressure Injury Prevalence Survey to differentiate perioperative versus inpatient unit PI.

Identification and classification of race as other in health care records undermines the ability of health care providers and researchers to identify and address the specific needs and challenges faced by various groups. For future studies, it would be beneficial to identify PPI risks between darker and lighter skin tone patients, instead of using race. Greater level of details may be needed for the social determinants.

Future Research Directions

Despite the findings of this study, several gaps remain in the understanding of PPI. Future research should focus on longitudinal studies that track the incidence and outcomes of PI across diverse surgical populations. In addition, randomized controlled trials are needed to evaluate the effectiveness of specific prevention strategies, such as repositioning protocols and the use of specialized support surfaces.

Multicenter studies would enhance the generalizability of findings and provide a more comprehensive understanding of the factors contributing to PI in various health care settings. As technology continues to advance, exploring the role of innovative solutions, such as subepidermal moisture and thermography for objective assessments, could significantly impact PPI earlier identification, prevention efforts, and continuity of care from the perioperative setting into the inpatient care units.

Future research should prioritize the collection of detailed information about the surgical environment and the equipment used. This approach will enhance our understanding of the multifactorial nature of PPI development and inform best practices for prevention.

CONCLUSIONS

This descriptive retrospective study identified that cardiovascular surgery remains a high risk for PPI in perioperative patients. Among the demographic characteristics, race is not a sufficient category for identifying risk for PPI as it lacks the accuracy in skin tone measurement. This study indicates a higher prevalence of PPI among older age groups as a contributing factor in the development of pressure injuries. The CCI is effective for assessing patient risk and can inform the development of specific preventative bundles tailored to individual comorbidities, ultimately enhancing patient care and improving outcomes. Special attention to reducing pressure on the back and buttocks during supine positioning is warranted. PPI may still occur despite individualized preventative efforts in the perioperative setting.

REFERENCES

1. Haisley M, Sørensen JA, Sollie M. Postoperative pressure injuries in adults having surgery under general anaesthesia: systematic review of perioperative risk factors. *Br J Surg* 2020;107(4):338-347.
2. Solmos S, Gefen A, Black J, Orlov A, Belo O, Cuddigan J. Medical device testing: methods, significance, and clinical applications. *Adv Skin Wound Care* 2023;36(10):513-522.
3. Yoshimura M, Ohura N, Santamaria N, Watanabe Y, Akizuki T, Gefen A. High body mass index is a strong predictor of intraoperative acquired pressure injury in spinal surgery patients when prophylactic film dressings are applied: A retrospective analysis prior to the BOSS Trial. *Int Wound J* 2020;17(3):660-669.
4. Pittman J, Horvath D, Beeson T, et al. Pressure injury prevention for complex cardiovascular patients in the operating room and intensive care unit. *J Wound Ostomy Continence Nurs* 2021;48(6):510-515.
5. Kim JY, Lee HH. Risk factors associated with pressure injuries in surgical patients: a retrospective case-control study. *J Wound Ostomy Continence Nurs* 2022;49(6):511-517.
6. Brindle T. Incidence and variables predictive of pressure injuries in patients undergoing ventricular assist device and total artificial heart surgeries: an 8-year retrospective cohort study. *Adv Skin Wound Care* 2020;33(12):651-660.
7. Strauss R, Preston A, Zalman DC, Rao AD. Silicone foam dressing for prevention of sacral deep tissue injuries among cardiac surgery patients. *Adv Skin Wound Care* 2019;32(3):139-142.
8. Bicket MC, Chua KP, Lagisetty P, et al. Prevalence of surgery among individuals in the United States. *Ann Surg Open* 2024;5(2):e421.
9. Rullán PJ, Xu JR, Emara AK, et al. Major National Shifts to Outpatient Total Knee Arthroplasties in the United States: a 10-year trends analysis of procedure volumes, complications, and healthcare utilizations (2010 to 2020). *J Arthroplasty* 2023;38(7):1209-16.e5.
10. Padula W, Berke C, Bryant R, For the NPIAP-WOCN-AAWC Joint Policy Task Force. A collaborative call for changes in reimbursement policies to achieve improvements in hospital safety related to pressure injuries. *J Patient Saf* 2021;17(4):e268.
11. Pham BD. *Cost-Effectiveness of Pressure Ulcer Prevention and Calibration Analysis of Decision-Analytic Models*. University of Toronto; 2015.
12. Saindon K, Berlowitz DR. Update on pressure injuries: a review of the literature. *Adv Skin Wound Care* 2020;33(8):403-409.
13. Berlowitz D, Forget JG, Saindon K. The 2022 update on pressure injuries: a review of the literature. *Adv Skin Wound Care* 2023;36(9):463-469.
14. Tervo-Heikkinen TA, Heikkilä A, Koivunen M, et al. Pressure injury prevalence and incidence in acute inpatient care and related risk factors: a cross-sectional national study. *Int Wound J* 2022;19(4):919-931.
15. Cox J, Schallom M. Pressure injuries in critical care patients: a conceptual schema. *Adv Skin Wound Care* 2021;34(3):124-131.
16. Alderden J, Johnny J, Brooks KR, et al. Explainable artificial intelligence for early prediction of pressure injury risk. *Am J Crit Care* 2024;33(5):373-381.
17. Speth J. Guidelines in practice: prevention of perioperative pressure injury. *AORN J* 2023;118(1):37-44.
18. Quan H, Sundararajan V, Halfon P, et al. Coding Algorithms for Defining Comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care* 2005;43(11):1130-1139.
19. Quan H, Li B, Couris CM, et al. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. *Am J Epidemiol* 2011;173(6):676-682.
20. Alderden J, Cummins M, Zaratkiewicz S, 'Lucy' Zhao Y, Drake K, Yap TL. Hospital-acquired pressure injury development among surgical critical care patients admitted with community-acquired pressure injury: a retrospective cohort study. *J Wound Ostomy Continence Nurs* 2020;47(5):470-476.
21. Yang Q, Li J, Shi D, et al. Incidence and risk factors associated with hospital-acquired pressure ulcers following total hip arthroplasty: a retrospective nationwide inpatient sample database study. *J Tissue Viability* 2022;31(2):332-338.
22. Aloweni FBAB, Lim SH, Agus NLB, et al. Evaluation of an evidence-based care bundle for preventing hospital-acquired pressure injuries in high-risk surgical patients. *AORN J* 2023;118(5):306-320.
23. Clements NA, Gaskins JT, Martin RCG. Predictive ability of comorbidity indices for surgical morbidity and mortality: a systematic review and meta-analysis. *J Gastrointest Surg* 2023;27(9):1971-1987.
24. Cheng H, Shao L, Wu H, Mi B, Li Q, Zhang J. Older adult sepsis survivors discharged to skilled nursing facilities: age-adjusted charlson comorbidity index as a predictor of 6-month mortality. *Nurs Crit Care* 2025;30(4):e70078.
25. Zhang Z, Yang H, Luo M. Association between Charlson Comorbidity Index and community-acquired pressure injury in older acute inpatients in a Chinese Tertiary Hospital. *Clin Interv Aging* 2021;16:1987-1995.
26. Elsorady KE, Nouh AH. Biomarkers and clinical features associated with pressure injury among geriatric patients. *Electron J Gen Med* 2023;20(1):em431.
27. Zhao J, Zhang LX, Zhong YL, et al. A 10-year prevalence survey and clinical features analysis of pressure injury in a tertiary hospital in China, 2009–2018. *Adv Skin Wound Care* 2021;34(3):150-156.
28. CDC. Social Determinants of Health. Public Health Professionals Gateway. May 15, 2024. Accessed June 29, 2024. https://www.cdc.gov/public-health-gateway/php/about/social-determinants-of-health.html
29. Chaves K, Gray D, Barton B, , et al 2019 National Healthcare Quality and Disparities Report.
30. Pittman J, Otts JA, Mulekar M. Enhanced skin assessment methodology to detect early tissue damage and prevent pressure injuries. *J Wound Ostomy Continence Nurs* 2024;51(3):191-198.
31. Pusey-Reid E, Quinn L, Samost ME, Reidy PA. Skin assessment in patients with dark skin tone. *AJN Am J Nurs* 2023;123(3):36-43.
32. Sasson DC, Duan K, Patel SM, Junn A, Hsia HC. The impact of social determinants of health on pressure injury progression: a retrospective chart and scoping review. *Adv Skin Wound Care* 2023;36(2):106-111.
33. Black J, Edsberg L, Baharestani M. Pressure ulcers: avoidable or unavoidable? Results of the National Pressure Ulcer Advisory Panel Consensus Conference. *Ostomy Wound Manag Prev* 2011;57(2):24-37; Accessed October 16, 2024. https://www.hmpgloballearningnetwork.com/site/wmp/content/pressure-ulcers-avoidable-or-unavoidable-results-national-pressure-ulcer-advisory-panel-cons
34. Black J, Cox J, Capasso V, et al. Current perspectives on pressure injuries in persons with dark skin tones from the National Pressure Injury Advisory Panel. *Adv Skin Wound Care* 2023;36(9):470-480.
35. Chen HL, Chen XY, Wu J. The incidence of pressure ulcers in surgical patients of the last 5 years: a systematic review. *Wounds* 2012;24(9):234-241.
36. Chen X, Liao H, Gao W, Chen Y, Huang J, Wei Y. Cardiopulmonary bypass duration and the incidence of pressure injuries in patients undergoing cardiovascular surgery: a retrospective cohort study. *J Wound Ostomy Continence Nurs* 2020;47(4):343-348.
37. Chello C, Lusini M, Schilirò D, Greco SM, Barbato R, Nenna A. Pressure ulcers in cardiac surgery: Few clinical studies, difficult risk assessment, and profound clinical implications. *Int Wound J* 2019;16(1):9-12.
38. Taghiloo H, Ebadi A, Saeid Y, Jalali Farahni A, Davoudian A. Prevalence and factors associated with pressure injury in patients undergoing open heart surgery: a systematic review and meta-analysis. *Int Wound J* 2022;20(6):2321-2333.
39. Kurt Y, Kaşikçi M, Malaska R. Nursing interventions to prevent pressure injury among open heart surgery patients: a systematic review. *Nurs Crit Care* 2024;29(6):1706-1720.
40. Łajczak P, Łajczak A, Buczkowski S, et al. An early evaluation of robot-assisted and conventional techniques for posterior approach atlantoaxial displacement instrumentation—a systematic review and meta-analysis. *Neurosurg Rev* 2025;48(1):105.

41. Guan J, Feng N, Yu X, Yang K. Comparison of robot-assisted versus fluoroscopy-guided transforaminal lumbar interbody fusion (TLIF) for lumbar degenerative diseases: a systematic review and meta-analysis of randomized controlled trails and cohort studies. *Syst Rev* 2024;13(1):170.
42. O'Connor R. *The Prevalence Rate of Pressure Ulcers in the Acute Hospital Setting and Investigating Three Methods of Prevalence Measurement*. Diss. Royal College of Surgeons in Ireland; 2016.
43. Ezeamuzie O, Darian V, Katiyar U, Siddiqui A. Intraoperative use of low-profile alternating pressure mattress for prevention of hospital acquired pressure injury. *Perioper Care Oper Room Manag* 2019;17:100080.
44. Guzman S, Allegretti AL, Kormos RL, Brienza DM. A comparison of air-cell and gel surgical table pads and an evaluation of the influence of pressure distribution and other factors on pressure injury prevention. *J Tissue Viability* 2021;30(1):9-15.
45. Techanivate A, Athibai N, Siripongsaporn S, Singhatanadgige W. Risk factors for facial pressure ulcers in patients who underwent prolonged prone orthopedic spine surgery. *Spine (Phil Pa 1976)* 2021;46(11):744-750.
46. Tang Z, Li N, Xu J. Construction of a risk prediction model for intraoperative pressure injuries: a prospective, observational study. *J Perianesth Nurs* 2021;36(5):473-479.
47. Suh D, Kim SY, Yoo B, Lee S. An exploratory study of risk factors for pressure injury in patients undergoing spine surgery. *Anesth Pain Med* 2021;16(1):108-115.
48. Munro CA, Jiang YH. Validity and reliability evidence of the Munro Scale for perioperative patients part II: construct validity. *J Nurs Meas* 2024;32(2):216-226.
49. Munro CA, Jiang YH. Validity and reliability evidence of the Munro Scale for perioperative patients, part I: correlation, multiple regression, and reliability. *J Nurs Meas* 2024;32(1):69-81.
50. Lopes CM, Haas VJ, Dantas RAS, Oliveira CG, Galvão CM. Assessment scale of risk for surgical positioning injuries. *Rev Lat Am Enfermagem* 2016;24:e2704.
51. Spruce L. Prevention of perioperative pressure injury. *AORN J* 2023;117(5):317-323.
52. Meehan AJ, Beinlich NR, Bena JF, Mangira C. Revalidation of a perioperative risk assessment measure for skin. *Nurs Res* 2019;68(5):398-404.

